No. 682 Vol. XIV

Jordan, David Starr
Book of Natural History

Date Due

JUN 18 1915			
NOV 9 - 1915			
MAY 29			
JUN 16			
MAR 1 9			

Digitized by the Internet Archive
in 2026

https://archive.org/details/youngfolkslibrar0000thom_v3u2

YOUNG FOLKS' LIBRARY

SELECTIONS FROM THE CHOICEST LITERATURE OF ALL LANDS: FOLK-LORE, FAIRY TALES, FABLES, LEGENDS, NATURAL HISTORY, WONDERS OF EARTH, SEA AND SKY, ANIMAL STORIES, SEA TALES, BRAVE DEEDS, EXPLORATIONS, STORIES OF SCHOOL AND COLLEGE LIFE, BIOGRAPHY, HISTORY, PATRIOTIC ELOQUENCE, POETRY

THIRD EDITION

REVISED IN CONFERENCE BY

THOMAS BAILEY ALDRICH, EDITOR-IN-CHIEF,
PRESIDENT WILLIAM JEWETT TUCKER,
HAMILTON WRIGHT MABIE, HENRY
VAN DYKE, NATHAN HASKELL DOLE

TWENTY VOLUMES *RICHLY ILLUSTRATED*

BOSTON
HALL AND LOCKE COMPANY
PUBLISHERS

Copyright, 1901, 1902,
By HALL & LOCKE COMPANY.
Boston, U. S. A.

Stanhope Press
F. H. GILSON COMPANY
BOSTON, U.S.A.

EDITORIAL BOARD

THOMAS BAILEY ALDRICH, Editor-in-chief,
Author, poet, former editor *Atlantic Monthly*, Boston, Mass.

The HON. GEORGE FRISBIE HOAR,
United States Senator, Worcester, Mass.

The HON. JOHN D. LONG,
Secretary of the United States Navy, Boston.

HAMILTON WRIGHT MABIE, LL.D.,
Author, literarian, associate editor *The Outlook*, New York.

ERNEST THOMPSON-SETON,
Artist, author, New York.

JOHN TOWNSEND TROWBRIDGE,
Author, poet, and editor, Arlington, Mass.

The REVEREND CYRUS TOWNSEND BRADY,
Archdeacon, author, Philadelphia.

JOEL CHANDLER HARRIS,
Humorous writer, Atlanta, Ga.

MARY HARTWELL CATHERWOOD,
Historical novelist, Chicago.

LAURA E. RICHARDS,
Author, Gardiner, Me.

ROSWELL FIELD,
Author, editor *The Evening Post*, Chicago.

TUDOR JENKS,
Author, associate editor *Saint Nicholas*, New York.

GEORGE A. HENTY,
Traveller, author, London, England.

KIRK MUNROE,
Writer of stories for boys, Cocoanut Grove, Fla.

EDITH M. THOMAS,
Poet, West New Brighton, N.Y.

CAROLINE TICKNOR,
Author, editor, Boston.

WILLIAM RAINEY HARPER, D.D., LL.D.,
President Chicago University.

DAVID STARR JORDAN, M.D., LL.D.,
President Leland Stanford Junior University, naturalist, writer, Stanford University, Cal.

CHARLES ELIOT NORTON, A.M., LL.D., etc.,
Scholar, author, Emeritus Professor of Art at Harvard University.

HENRY VAN DYKE, D.D., LL.D.,
Clergyman, author, Professor Princeton University.

The REVEREND THOMAS J. SHAHAN,
Dean of the Faculty of Divinity, Professor of Early Ecclesiastical History, Catholic University, Washington, D.C.

WILLIAM P. TRENT,
Author, editor, Professor of English Literature, Columbia University, New York City.

EDWARD SINGLETON HOLDEN, A.M., LL.D.,
Ex-president University of California, astronomer, author, U.S. Military Academy, West Point.

EDWIN ERLE SPARKS,
Professor of American History, Chicago University.

The VERY REV. GEORGE M. GRANT, D.D., LL.D.,
Educator, author, vice-principal Queen's College, Kingston, Ont.

NATHAN HASKELL DOLE,
Author, translator, literary editor *Current History*, Boston.

ABBIE FARWELL BROWN,
Author, Boston.

CHARLES WELSH, Managing Editor,
Author, lecturer, editor, Winthrop Highlands, Mass.

LIST OF VOLUMES

VOLUME I.

THE STORY TELLER
Edited by CHARLES ELIOT NORTON

VOLUME II.

THE MERRY MAKER
Edited by JOEL CHANDLER HARRIS

VOLUME III.

FAMOUS FAIRY TALES
Edited by ROSWELL FIELD

VOLUME IV.

TALES OF FANTASY
Edited by TUDOR JENKS

VOLUME V.

MYTHS AND LEGENDS
Edited by THOMAS J. SHAHAN

VOLUME VI.

THE ANIMAL STORY BOOK
Edited by ERNEST THOMPSON-SETON

VOLUME VII.

SCHOOL AND COLLEGE DAYS
Edited by KIRK MUNROE and MARY HARTWELL CATHERWOOD

VOLUME VIII.

BOOK OF ADVENTURE
Edited by NATHAN HASKELL DOLE

VOLUME IX.

FAMOUS EXPLORERS
Edited by EDWIN ERLE SPARKS

VOLUME X.

BRAVE DEEDS
Edited by JOHN TOWNSEND TROWBRIDGE

VOLUME XI.

WONDERS OF EARTH, SEA, AND SKY
Edited by EDWARD SINGLETON HOLDEN

VOLUME XII.

FAMOUS TRAVELS
Edited by GEORGE A. HENTY

VOLUME XIII.

SEA STORIES
Edited by CYRUS TOWNSEND BRADY

VOLUME XIV.

A BOOK OF NATURAL HISTORY
Edited by DAVID STARR JORDAN

VOLUME XV.

HISTORIC SCENES IN FICTION
Edited by HENRY VAN DYKE

VOLUME XVI.

FAMOUS BATTLES BY LAND AND SEA
Edited by JOHN D. LONG

VOLUME XVII.

MEN WHO HAVE RISEN
Edited by HAMILTON WRIGHT MABIE

VOLUME XVIII.

BOOK OF PATRIOTISM
Edited by GEORGE FRISBIE HOAR

VOLUME XIX.

LEADERS OF MEN, OR HISTORY TOLD IN BIOGRAPHY
Edited by WILLIAM RAINEY HARPER

VOLUME XX.

FAMOUS POEMS
Selected by THOMAS BAILEY ALDRICH, with Poetical Foreword by EDITH M. THOMAS.

Purchased by the
SIMON NEWMAN FUND
FOR THE
Public Library of Newman

THE CONDOR

Young Folks' Library in Twenty Volumes
Thomas Bailey Aldrich, Editor-in-Chief

A BOOK OF NATURAL HISTORY

EDITED BY

DAVID STARR JORDAN

VOLUME XIV

BOSTON
HALL AND LOCKE COMPANY
PUBLISHERS

Copyright, 1901, 1902,
By HALL & LOCKE COMPANY.
Boston, U. S. A.

Stanhope Press
F. H. GILSON COMPANY
BOSTON, U.S.A.

CONTENTS

PAGE

List of Illustrations xiii

Animals, Birds, and Fishes xv
By David Starr Jordan.

The Wonder of Life 1
By Professor T. H. Huxley.

Life Growth; — Frogs 10
By Margaret Warner Morley.

The Man-Like Apes 15
By Professor T. H. Huxley.

Some Strange Nurseries 46
By Grant Allen.

How Animals Spend the Winter 69
By W. S. Blatchley.

Birds' Nests 88
By John Burroughs.

Birds in Their Relation to Agriculture 121
By Lawrence Bruner.

The Scissor Beak 143
By Charles Darwin.

The Condor 146
By Charles Darwin.

The Umbrella Bird 153
By Sir A. R. Wallace.

Humming Birds 155
By Thomas G. Belt, F.G.S.

The Foundations of a Wonderful City 158
By Maurice Maeterlinck.

Wasps 175
By Thomas G. Belt, F.G.S.

A Wasp and Its Prey 180
By G. W. and E. G. Peckham.

Leaf-Cutting Ants 190
By Thomas G. Belt, F.G.S.

Some Wonderful Spiders 197
By Charles Darwin.

What I Saw in an Ant's Nest 201
By Andrew Wilson.

PAGE

The Wild Llama 228
By Charles Darwin.

Bats 233
By W. S. Dallas, F.G.S.

How Snakes Eat 260
By Catherine C. Hopley.

What Worms Do 266
By Charles Darwin.

Two Fops Among the Fishes 286
By W. S. Blatchley.

Sea Slugs and Cuttle-Fish 294
By Charles Darwin.

The Cow Fish 297
By Sir Alfred Russell Wallace.

Old Rattler and the King Snake 299
By David Starr Jordan.

The Story of a Strange Land 305
By David Starr Jordan.

The Color of Animals 315
By Sir John Lubbock Bart.

Protective Resemblances in Spiders 343
By E. G. Peckham.

The Bath of the Birds 369
By Richard Jefferies.

The Loon 378
By Henry D. Thoreau.

The Dartmoor Ponies 384
By Arabella R. Buckley.

Biographical Notes 396

Suggestions for Supplementary Reading 398

NOTE.

The publishers' acknowledgments are due to Miss Margaret Warner Morley and Messrs. A. C. McClurg & Co. for permission to use "Life Growth,— Frogs"; to Mr. W. S. Blatchley and *The Popular Science Monthly* for "How Animals Spend the Winter" and "Two Fops Among the Fishes"; to Messrs. Houghton, Mifflin & Co. for "Birds' Nests," by John Burroughs; to Mr. L. Bruner and the Nebraska Ornithologists' Union for "Birds in Their Relation to Agriculture"; to G. W. and E. G. Peckham for "A Wasp and Its Prey" and "Protective Resemblances in Spiders"; to President David Starr Jordan and *The Popular Science Monthly* for "Old Rattler and the King Snake"; to President Jordan and A. C. McClurg & Co. for "The Story of a Strange Land."

LIST OF COLORED ILLUSTRATIONS

	PAGE
The Condor	*Frontispiece*
The Gorilla	*Face Page* 40
The Yellow Bellied Woodpecker	96
The Umbrella Bird	152
The Guanaco	230
The Vampire Bat	240
The Cow Fish	296

And One Hundred and Forty-two Black and White Illustrations in the Text.

Purchased by the
SIMON NEWMAN FUND
FOR THE
Public Library of Newman

ANIMALS, BIRDS, AND FISHES

BY

DAVID STARR JORDAN, LL.D.

THIS volume is made up from the writings of naturalists who have told us of the behavior of animals as they have seen it at first hand and of the beginnings and the growth of life so far as they know about it. In selecting these from the wealth of available material the editor has been guided by this rule: The subject matter must be interesting to young people; it must be told in a clear and attractive style; and most important of all, it must deal with actualities. We have seen in the last few years a marked revival of nature studies. This has led to a wider range of interest in natural phenomena and in the growth and ways of animals and plants. If this movement is not to be merely a passing fad, the element of truthfulness must be constantly insisted upon. If a clever imagination, or worse, sentimental symbolism, be substituted for the truth of nature, the value of such studies is altogether lost.

The essence of character-building lies in action. The chief value of nature study in character-building is that,

like life itself, it deals with realities. One must in life make his own observations, frame his own inductions, and apply them in action as he goes along. The habit of finding out the best thing to do next and then doing it is the basis of character. Nature-study, if it be genuine, is essentially doing. To deal with truth is necessary, if we are to know truth when we see it in action. The rocks and shells, the frogs and lilies, always tell the absolute truth. Every leaf on the tree is an original document in botany. When a thousand are used or used up, the archives of Nature are just as full as ever. By the study of realities wisdom is built up. In the relations of objects he can touch and move, the child finds the limitations of his powers, the laws that govern phenomena, which his own actions must obey. So long as he deals with realities, these laws stand in their proper relation. "So simple, so natural, so true," says Agassiz. "This is the charm of dealing with nature herself. She brings us back to absolute truth so often as we wander."

So long as a child is led from one reality to another, never lost in words or abstractions, — so long this natural relation remains. "What can I do with it?" is the beginning of wisdom. "What is it to me?" is the beginning of personal virtue.

By adding near things to near, the child grows in Knowledge. Knowledge, tested and set in order, is Science. Nature-study is the beginning of science.

It is the science of the child. The "world as it is" is the province of science. In proportion as our actions conform to the conditions of the world as it is, do we find the world beautiful, glorious, divine. The truth of the world as it is must be the final inspiration of art, poetry, and religion. The world, as men have agreed to say that it is, is quite another matter. The less our children hear of this, the less they may have to unlearn. Nature studies have long been valued as "a means of grace," because they arouse the enthusiasm, the love of work, which belongs to open-eyed youth. The child blasé with moral precepts and irregular conjugations turns with fresh delight to the unrolling of ferns or the song of birds.

Nature must be questioned in earnest, or she will not reply. But to every serious question she will return a serious answer. "Simple, natural, and true," she tends to create simplicity and truth. Truth and virtue are but opposite sides of the same shield. As leaves pass over into flowers, and flowers into fruit, so are wisdom, virtue, and happiness inseparably related.

This little volume is a contribution to the subject matter of Nature Study. It is the work of students of nature, and their work is "simple, natural, and true," in so far as it is represented here.

David Starr Jordan.

Leland Stanford Jr. University,
California, *April* 22, 1902.

A BOOK OF NATURAL HISTORY

THE WONDER OF LIFE

(From His Science Primer, Introduction.)

By PROFESSOR, T. H. HUXLEY.

EVERY one has seen a cornfield. If you pluck up one of the innumerable wheat plants which are fixed in the soil of the field, about harvest time, you will find that it consists of a stem which ends in a root at one end and an ear at the other, and that blades or leaves are attached to the sides of the stem. The ear contains a multitude of oval grains which are the seeds of the wheat plant. You know that when these seeds are cleared from the husk or bran in which they are enveloped, they are ground into fine powder in mills, and that this powder is the flour of which bread is made. If a handful of flour mixed with a little cold water is tied up in a coarse cloth bag, and the bag is then put into a large vessel of water and well kneaded with the hands, it will become pasty, while the water will become white. If this water is poured away into another vessel, and

the kneading process continued with some fresh water, the same thing will happen. But if the operation is repeated the paste will become more and more sticky, while the water will be rendered less and less white, and at last will remain colorless. The sticky substance which is thus obtained by itself is called gluten; in commerce it is the substance known as maccaroni.

If the water in which the flour has thus been washed is allowed to stand for a few hours, a white sediment will be found at the bottom of the vessel, while the fluid above will be clear and may be poured off. This white sediment consists of minute grains of starch, each of which, examined with the microscope, will be found to have a concentrically laminated structure. If the fluid from which the starch was deposited is now boiled it will become turbid, just as white of egg diluted with water does when it is boiled, and eventually a whitish lumpy substance will collect at the bottom of the vessel. This substance is called vegetable albumin.

Besides the albumin, the gluten, and the starch, other substances about which this rough method of analysis gives us no information, are contained in the wheat grain. For example, there is woody matter or cellulose, and a certain quantity of sugar and fat. It would be possible to obtain a substance similar to albumin, starch, saccharine, and fatty matters, and cellulose, by treating the stem, leaves, and root in a similar fashion, but the cellulose would be in far larger proportion. Straw, in fact, which consists of the dry stem and leaves of the wheat plant, is almost wholly made up of cellulose. Besides this, however,

it contains a certain proportion of mineral bodies, among them, pure flint or silica; and, if you should ever see a wheat rick burnt, you will find more or less of this silica, in a glassy condition, in the embers. In the living plant, all these bodies are combined with a large proportion of water, or are dissolved, or suspended in that fluid. The relative quantity of water is much greater in the stem and leaves than in the seed.

Everybody has seen a common fowl. It is an active creature which runs about and sometimes flies. It has a body covered with feathers, provided with two wings and two legs, and ending at one end in a neck terminated by a head with a beak, between the two parts of which the mouth is placed. The hen lays eggs, each of which is inclosed in a hard shell. If you break an egg the contents flow out and are seen to consist of the colorless glairy "white" and the yellow "yolk." If the white is collected by itself in water and then heated it becomes turbid, forming a white solid, very similar to the vegetable albumin, which is called animal albumin.

If the yolk is beaten up with water, no starch nor cellulose is obtained from it, but there will be plenty of fatty and some saccharine matter, besides substances more or less similar to albumin and gluten.

The feathers of the fowl are chiefly composed of horn; if they are stripped off and the body is boiled for a long time, the water will be found to contain a quantity of gelatin, which sets into a jelly as it cools; and the body will fall to pieces, the bones and the flesh separating from one another. The bones

consist almost entirely of a substance which yields gelatin when it is boiled in water, impregnated with a large quantity of salts of lime, just as the wood of the wheat stem is impregnated with silica. The flesh, on the other hand, will contain albumin, and some other substances which are very similar to albumin, termed fibrim and syntonin.

In the living bird, all these bodies are united with a great quantity of water, or dissolved, or suspended in water; and it must be remembered that there are sundry other constituents of the fowl's body and of the egg, which are left unmentioned, as of no present importance.

The wheat plant contains neither horn, nor gelatin, and the fowl contains neither starch, nor cellulose; but the albumin of the plant is very similar to that of the animal, and the fibrin and syntonin of the animal are bodies closely allied to both albumin and gluten.

That there is a close likeness between all these bodies is obvious from the fact that when any of them is strongly heated, or allowed to putrefy, it gives off the same sort of disagreeable smell; and careful chemical analysis has shown that they are, in fact, all composed of the elements carbon, hydrogen, oxygen, and nitrogen, combined in very nearly the same proportions. Indeed, charcoal, which is impure carbon, might be obtained by strongly heating either a handful of corn, or a piece of fowl's flesh, in a vessel from which the air is excluded so as to keep the corn or the flesh from burning. And if the vessel were a still, so that the products of this destructive distillation, as it is called, could be condensed and collected, we should

find water and ammonia, in some shape or other, in the receiver. Now ammonia is a compound of the elementary bodies, nitrogen and hydrogen; therefore both nitrogen and hydrogen must have been contained in the bodies from which it is derived.

It is certain, then, that very similar nitrogenous compounds form a very large part of the bodies of both the wheat plant and the fowl, and these bodies are called proteids.

It is a very remarkable fact that not only are such substances as albumin, gluten, fibrin, and syntonin, known exclusively as products of animal and vegetable bodies, but that every animal and every plant, at all periods of its existence, contains one or other of them, though, in other respects, the composition of living bodies may vary indefinitely. Thus, some plants contain neither starch nor cellulose, while these substances are found in some animals; while many animals contain no horny matter and no gelatin-yielding substance. So that the matter which appears to be the essential foundation of both the animal and the plant is the proteid united with water; though it is probable that, in all animals and plants, these are associated with more or less fatty and amyloid (or starchy and saccharine) substances, and with very small quantities of certain mineral bodies, of which the most important appear to be phosphorus, iron, lime, and potash.

Thus there is a substance composed of water + proteids + fat + amyloids + mineral matters which is found in all animals and plants; and, when these are alive, this substance is termed protoplasm.

The wheat plant in the field is said to be a living

thing; the fowl running about the farmyard is also said to be a living thing. If the plant is plucked up, and if the fowl is knocked on the head, they soon die and become dead things. Both the fowl and the wheat plant, as we have seen, are composed of the same elements as those which enter into the composition of mineral matter, though united into compounds which do not exist in the mineral world. Why, then, do we distinguish this matter when it takes the shape of a wheat plant or a fowl, as living matter?

In the spring a wheat-field is covered with small green plants. These grow taller and taller until they attain many times the size which they had when they first appeared; and they produce the heads of flowers which eventually change into ears of corn.

In so far as this is a process of growth, accompanied by the assumption of a definite form, it might be compared with the growth of a crystal of salt in brine: but, on closer examination, it turns out to be something very different. For the crystal of salt grows by taking to itself the salt contained in the brine, which is added to its exterior; whereas the plant grows by addition to its interior: and there is not a trace of the characteristic compounds of the plant's body, albumin, gluten, starch, or cellulose, or fat, in the soil, or in the water, or in the air.

Yet the plant creates nothing; and, therefore, the matter of the proteins and amyloids and fats which it contains must be supplied to it, and simply manufactured, or combined in new fashions, in the body of the plant.

It is easy to see, in a general way, what the raw

materials are which the plant works up, for the plant gets nothing but the materials supplied to it by the atmosphere and by the soil. The atmosphere contains oxygen and nitrogen, a little carbonic acid gas, a minute quantity of ammoniacal salts, and a variable proportion of water. The soil contains clay and sand (silica), lime, iron, potash, phosphorus, sulphur, ammoniacal salts, and other matters which are of no importance. Thus, between them, the soil and the atmosphere contain all the elementary bodies which we find in the plant; but the plant has to separate them and join them together afresh.

Moreover, the new matter, by the addition of which the plant grows, is not applied to its outer surface, but is manufactured in its interior; and the new molecules are diffused among the old ones.

The grain of wheat is a part of the flower of the wheat plant, which, when it becomes ripe, is easily separated. It contains a minute and rudimentary plant; and, when it is sown, this gradually grows, or becomes developed into, the perfect plant, with its stem, roots, leaves, and flowers, which again give rise to similar seeds. No mineral body runs through a regular series of changes of form and size, and then gives off parts of its substance which take the same course. Mineral bodies present no such development, and give off no seeds or germs. They do not reproduce their kind.

The fowl in the farmyard is incessantly pecking about and swallowing now a grain of corn, and now a fly or a worm. In fact, it is feeding, and, as every one knows, would soon die if not supplied with food.

It is also a matter of every-day knowledge that it would not be of much use to give a fowl the soil of a corn-field, with plenty of air and water, to eat.

In this respect, the fowl is like all other animals; it cannot manufacture the proteid materials of its body, but it has to take them ready made, or in a condition which requires but very slight modification by devouring the bodies either of other animals or of plants. The animal or vegetable substances devoured are taken into the animal's stomach; they are there digested or dissolved; and thus they are fitted to be distributed to all parts of the fowl's own body, and applied to its maintenance and growth.

The fowl's egg is formed in the body of the hen, and is, in fact, part of her body inclosed in a shell and detached. It contains a minute rudiment of a fowl; and when it is kept at a proper temperature by the hen's sitting upon it, or otherwise for three weeks, this rudiment grows, or develops, at the expense of the materials contained in the yolk and the white, into a small bird, the chick, which is then hatched and grows into a fowl. The animal, therefore, is produced by the development of a germ in the same way as the plant; and, in this respect, all plants and all animals agree with one another, and differ from all mineral matter.

Thus there is a very broad distinction between mineral matter and living matter. The elements of living matter are identical with those of mineral bodies; and the fundamental laws of matter and motion apply as much to living matter as to mineral matter; but every living body is, as it were, a complicated piece of mechanism which "goes," or lives, only under certain

conditions. The germ contained in the fowl's egg requires nothing but a supply of warmth, within certain narrow limits of temperature, to build the molecules of the egg into the body of the chick. And the process of development of the egg, like that of the seed, is neither more nor less mysterious than that, in virtue of which, the molecules of water, when it is cooled down to the freezing-point, build themselves up into regular crystals.

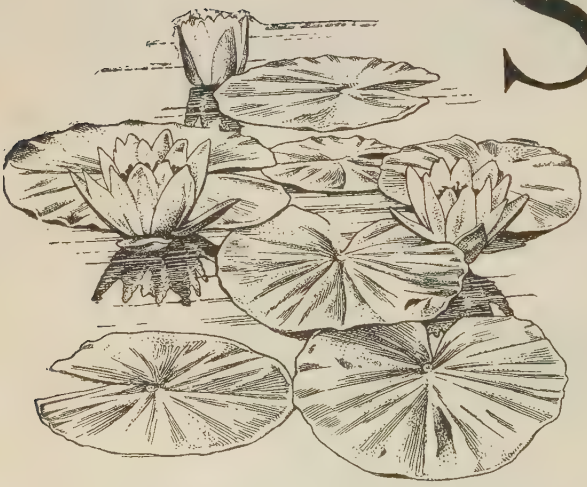
The further study of living bodies leads to the province of biology, of which there are two great divisions — botany, which deals with plants, and zoölogy, which treats of animals.

Each of these divisions has its subdivisions — such as morphology, which treats of the form, structure, and development of living beings, and physiology, which explains their actions or functions, besides others.

LIFE GROWTH; — FROGS

(From A Song of Life.)

By MARGARET WARNER MORLEY.[1]



SOMEWHAT higher than the fish in the scale of life is the frog. Although he begins life as a fish, and in the tadpole state breathes by gills, he soon discards the water-diluted air of the pond, and with perfect lungs boldly inhales the pure air of the upper world. His life as a tadpole, although so fish-like, is much inferior to true fish life: for though the fish has not the perfect lung, he has a modification of it which he fills with air, not for breathing purposes,

[1] Copyright by A. C. McClurg & Co., 1891.

but as an air-sac to make him float like a bubble in the water. Will he rise to the surface? he inflates the air-bladder. Will he sink to the bottom? he compresses the air-bladder. But in the frog the air-bladder changes into the lungs, and is never the delicate balloon which floats the fish in aqueous space. When the frog's lungs are perfected, his gills close, and he forever abandons fish-life, though being a cold-blooded creature he needs comparatively little air, and delights to return to his childhood's home in the bottom of the pond. But although he can stay under water for a long time, he is obliged to hold his breath while there, and when he would breathe must come to the surface to do so. It is possible to drown him by holding him under water.

A Frog.

As a feeder the frog relies upon animal life, which he expertly seizes with a tongue fastened by the wrong end, as compared with our tongues. He is a certain marksman, and when he aims at an insect the chances are that the insect will enter his stomach and be there speedily changed into a new form of animal life.

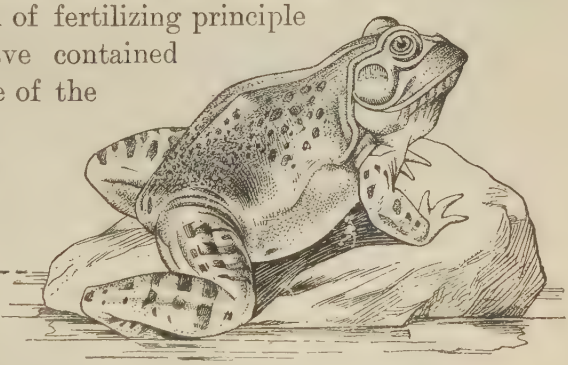
Although from the moment the gills disappear the frog is a true land animal, he is obliged, on account of the fish-like character of his young, to lay his eggs in the water. For this purpose the frogs enter the pools in early spring. The surface of every country pond swarms with the bright-eyed little creatures. They

have awakened from a long, cold, winter sleep, to find the spring about them and within them. Life has suddenly become abundant and joyous. Their sluggish blood flows faster, their hearts beat quicker; they leap, they swim, they swell out their throats and call to each other in various keys. The toads are with them, and the pretty tree-frogs that change their color to suit their emotions. And all are rapturously screaming. Their voices are not musical, according to man's standard, but seem to afford great satisfaction to the performers in the shrill orchestra of the swamps, who thus give vent to the flood of life that sweeps through them after the still, icy winter.

As though the new spring-life were too plentiful to find room in the frogs and toads already existing, it calls for more frogs and toads; and new creatures are born to share the extra vitality. Like the flowers and the fish, the frogs, too, give forth new life. Within them, too, the miracle is performed. The tiny eggs of the one wake up and begin to grow. The tiny living bodies in the fertilizing principle of the other also wake up and begin to grow. But higher life is better guarded, because less prolific. The frog and the toad lay but few eggs as compared with the fish. Fish eggs may drop under the stones or float away, and so escape the vital touch of the fertilizing principle. There are so many that numbers may be lost and yet enough remain to continue the family. Not so with the frog family. No egg may be lost. So we find that the eggs of the frog are not dropped singly, like so many shot, but are bound together by a colorless, transparent, jelly-like substance, much like that found in the morn-

ing-glory seed, and which like that supplies nourishment to the young life, for the tadpole feeds upon it until he is able to seek other food. Moreover, instinct has taught the frog the need of extreme caution in the act of fertilization. Every egg *must* be fertilized. As the time draws near for the dropping of the few eggs into the water, the male frog so places himself that the moment the eggs are being laid, he pours over them, one by one, as they fall into the water, the fertilizing fluid.

And thus the mystery of life is again repeated. The union of the living, microscopic bodies of the fertilizing principle with the new laid egg is followed by the growth of the two elements into a living creature, able to eat, to breathe, to see, to feel. In some unknown way the atom of fertilizing principle seems to have contained the whole life of the father-frog, for it can give to his sons and daughters any of his peculiarities, either of color, form, motion, or disposition; and the tiny egg seems to have contained the whole life of the mother-frog, and can give to her sons and daughters any of her peculiarities; though, as is true of all inheritance, the tadpoles, as the young frogs are called, share the natures of both parents, inheriting some peculiarities from the father and others from the mother.



A Frog.

But, like other life, although the frogs may vary a good deal within frog limits, none of them can escape their own limits and enter into those of any other life. Once a frog, always a frog; and no frog-egg may hope to develop into a turtle, or a bird, or anything but a frog. The life in the fertilizing principle of the frog is sacred to frog eggs, and is lifeless in contact with any other.

Our common frogs, like many of the fishes, do not trouble themselves about the fate of their eggs after they are carefully laid in a safe place. They trust Mother Nature to see the little tadpoles safely through the perils of childhood, to help them change their dresses and get rid of their tails, and cut, not their teeth, but their arms and legs.

In Venezuela, however, there dwells a frog with well developed maternal instinct. The mothers have pockets on their backs, not for their own convenience, but as cradles for their babies. The fathers put the fertilized eggs into the pockets of the mothers; and there they remain, well guarded, until the young are able to care for themselves.

TADPOLES.

THE MAN-LIKE APES

(From Evidence as to Man's Place in Nature.)

By PROFESSOR T. H. HUXLEY.

Head of Gorilla.

SOUND knowledge respecting the habits and mode of life of the man-like Apes has been even more difficult of attainment than correct information regarding their structure.

Once in a generation, a Wallace may be found physically, mentally, and morally qualified to wander unscathed through the tropical wilds of America and of Asia, to form magnificent collections as he wanders, and withal to think out sagaciously the conclusions suggested by his collections; but, to the ordinary explorer or collector, the dense forests of equatorial Asia and Africa, which constitute the favorite habitation of the Orang, the Chimpanzee, and the

Gorilla, present difficulties of no ordinary magnitude; and the man who risks his life by even a short visit to the malarious shores of those regions may well be excused if he shrinks from facing the dangers of the interior; if he contents himself with stimulating the industry of the better-seasoned natives, and collecting and collating the more or less mythical reports and traditions with which they are too ready to supply him.

In such a manner most of the earlier accounts of the habits of the man-like Apes originated; and even now a good deal of what passes current must be admitted to have no very safe foundation. The best information we possess is that based almost wholly on direct European testimony respecting the Gibbons; the next best evidence relates to the Orangs; while our knowledge of the habits of the Chimpanzee and the Gorilla stands much in need of support and enlargement by additional testimony from instructed European eye-witnesses.

It will therefore be convenient in endeavoring to form a notion of what we are justified in believing about these animals, to commence with the best known man-like Apes, the Gibbons, and Orangs; and to make use of the perfectly reliable information respecting them as a sort of criterion of the probable truth or falsehood of assertions respecting the others.

Of the Gibbons, half a dozen species are found scattered over the Asiatic Islands, Java, Sumatra, Borneo, and through Malacca, Siam, Arracan, and an uncertain extent of Hindostan on the mainland of Asia. The largest attain a few inches above three feet in height, from the crown to the heel, so that they are shorter than the other man-like Apes, while the slenderness of

their bodies renders their mass far smaller in proportion even to this diminished height.

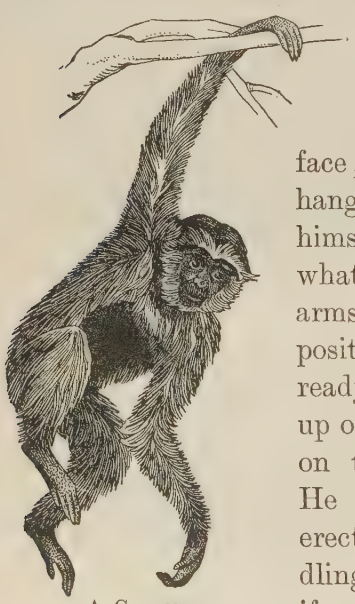
Dr. Salomon Müller, an accomplished Dutch naturalist, who lived for many years in the Eastern Archipelago, and to the result of whose personal experience I shall frequently have occasion to refer, states that the Gibbons are true mountaineers, loving the slopes and edges of the hills, though they rarely ascend beyond the limit of the fig-trees. All day long they haunt the tops of the tall trees, and though toward evening, they descend in small troops to the open ground, no sooner do they spy a man than they dart up the hillsides and disappear in the darker valleys.

All observers testify to the prodigious volume of voice possessed by these animals. According to the writer whom I have just cited, in one of them, the Siamang, "the voice is grave and penetrating, resembling the sounds gōek, gōek, gōek, gōek, goek ha ha ha ha haaāāā, and may be easily heard at a distance of half a league." While the cry is being uttered, the great membranous bag under the throat which communicates with the organ of voice, the so-called "laryngeal sac," becomes greatly distended, diminishing again when the creature relapses into silence.

M. Duvaucel, likewise, affirms that the cry of the Siamang may be heard for miles — making the woods ring again. So Mr. Martin describes the cry of the agile Gibbon as "overpowering and deafening" in a room, and "from its strength, well calculated for resounding through the vast forests." Mr. Waterhouse, an accomplished musician as well as zoölogist, says, "The Gibbon's voice is certainly much more powerful

than that of any singer I ever heard." And yet it is to be recollected that this animal is not half the height of, and far less bulky in proportion than, a man.

There is good testimony that various species of Gibbon readily take to the erect posture. Mr. George Bennett, a very excellent observer, in describing the habits of a male *Hylobates syndactylus* which remained for some time in his possession, says: "He invariably walks in the erect posture when on a level surface; and then the arms either hang down, enabling him to assist himself with his knuckles; or, what is more usual, he keeps his arms uplifted in nearly an erect position, with the hands pendent ready to seize a rope, and climb up on the approach of danger or on the obtrusion of strangers. He walks rather quick in the erect posture, but with a waddling gait, and is soon run down if, while pursued, he has no opportunity of escaping by climbing. . . . When he walks in the erect posture, he turns the leg and foot outward, which occasions him to have a waddling gait and to seem bow-legged."



A Gibbon.

Dr. Burrough states of another Gibbon, the Horlack or Hooluk:

"They walk erect; and when placed on the floor, or in an open field, balance themselves very prettily by

raising their hands over their head and slightly bending the arm at the wrist and elbow, and then run tolerably fast, rocking from side to side; and, if urged to greater speed, they let fall their hands to the ground, and assist themselves forward, rather jumping than running, still keeping the body, however, nearly erect."

Somewhat different evidence, however, is given by Dr. Winslow Lewis:

"Their only manner of walking was on their posterior or inferior extremities, the others being raised upward to preserve their equilibrium, as rope-dancers are assisted by long poles at fairs. Their progression was not by placing one foot before the other, but by simultaneously using both, as in jumping." Dr. Salomon Müller also states that the Gibbons progress upon the ground by short series of tottering jumps, effected only by the hind limbs, the body being held altogether upright.

But Mr. Martin, who also speaks from direct observation, says of the Gibbons generally:

"Pre-eminently qualified for arboreal habits, and displaying among the branches amazing activity, the Gibbons are not so awkward or embarrassed on a level surface as might be imagined. They walk erect with a waddling or unsteady gait, but at a quick pace, the equilibrium of the body requiring to be kept up, either by touching the ground with the knuckles, first on one side then on the other, or by uplifting the arms so as to poise it. As with the Chimpanzee, the whole of the narrow, long sole of the foot is placed upon the ground at once, and raised at once, without any elasticity of step."

After this mass of concurrent and independent testimony, it cannot reasonably be doubted that the Gibbons commonly and habitually assume the erect attitude.

But level ground is not the place where these animals can display their very remarkable and peculiar locomotive powers, and that prodigious activity which almost tempts one to rank them among flying, rather than among ordinary climbing mammals.

Mr. Martin has given so excellent and graphic an account of the movements of a *Hylobates agilis*, living in the Zoölogical Gardens, in 1840, that I will quote it in full:

"It is almost impossible to convey in words an idea of the quickness and graceful address of her movements: they may indeed be termed aërial, as she seems merely to touch in her progress the branches among which she exhibits her evolutions. In these feats her hands and arms are the sole organs of locomotion, her body, hanging as if suspended by a rope, sustained by one hand (the right, for example), she launches herself, by an energetic movement, to a distant branch, which she catches with the left hand; but her hold is less than momentary; the impulse for the next launch is acquired; the branch then aimed at is attained by the right hand again, and quitted instantaneously, and so on, in alternate succession. In this manner spaces of twelve and eighteen feet are cleared, with the greatest ease and uninterruptedly, for hours together, without the slighest appearance of fatigue being manifested; and it is evident that, if more space could be allowed, distances very greatly exceeding eighteen feet would

be as easily cleared; so that Duvaucel's assertion that he has seen these animals launch themselves from one branch to another, forty feet asunder, startling as it is, may be well credited. Sometimes, on seizing a branch in her progress, she will throw herself, by the power of one arm only, completely round it, making a revolution with such rapidity as almost to deceive the eye, and continue her progress with undiminished velocity. It is singular to observe how suddenly this Gibbon can stop, when the impetus giving by the rapidity and distance of her swinging leaps would seem to require a gradual abatement of her movements. In the very midst of her flight a branch is seized, the body raised, and she is seen, as if by magic, quietly seated on it, grasping it with her feet. As suddenly she again throws herself into action.

"The following facts will convey some notion of her dexterity and quickness. A live bird was let loose in her apartment; she marked its flight, made a long swing to a distant branch, caught the bird with one hand in her passage, and attained the branch with her other hand, her aim, both at the bird and at the branch, being as successful as if one object only had engaged her attention. It may be added that she instantly bit off the head of the bird, picked its feathers, and then threw it down without attempting to eat it.

"On another occasion this animal swung herself from a perch, across a passage at least twelve feet wide, against a window which it was thought would be immediately broken: but not so; to the surprise of all, she caught the narrow framework between the panes with her hand, in an instant attained the proper im-

petus, and sprang back again to the cage she had left — a feat requiring not only great strength, but the nicest precision."

The Gibbons appear to be naturally very gentle, but there is very good evidence that they will bite severely when irritated, a female *Hylobates agilis* having so severely lacerated one man with her long canines that he died; while she had injured others so much that, by way of precaution, these formidable teeth had been filed down; but if threatened she would still turn on her keeper. The Gibbons eat insects, but appear generally to avoid animal food. A Siamang, however, was seen by Mr. Bennett to seize and devour greedily a live lizard. They commonly drink by dipping their fingers in the liquid and then licking them. It is asserted that they sleep in a sitting posture.

Duvaucel affirms that he has seen the females carry their young to the water-side and there wash their faces, in spite of resistance and cries. They are gentle and affectionate in captivity — full of tricks and pettishness, like spoiled children, and yet not devoid of a certain conscience, as an anecdote, told by Mr. Bennett will show. It would appear that his Gibbon had a peculiar inclination for disarranging things in the cabin. Among these articles a piece of soap would especially attract his notice, and for the removal of this he had been once or twice scolded. "One morning," says Mr. Bennett, "I was writing, the Ape being present in the cabin, when, casting my eyes toward him, I saw the little fellow taking the soap. I watched him without him perceiving that I did so: and he occasionally would cast a furtive glance toward the place

where I sat. I pretended to write; he seeing me busily occupied, took the soap, and moved away with it in his paw. When he had walked half the length of the cabin, I spoke quietly, without frightening him. The instant he found I saw him he walked back again and deposited the soap nearly in the same place from whence he had taken it. There was certainly something more than instinct in that action: he evidently betrayed a consciousness of having done wrong both by his first and last actions — and what is reason if that is not an exercise of it?"

The most elaborate account of the natural history of the Orang-Utan extant is that given in the "*Verhandelingen over de Natuurlijke Geschiedenis der Nederlandsche overzeeche Bezittingen* (*1839–45*)," by Dr. Salomon Müller and Dr. Schlegel, and I shall base what I have to say upon this subject almost entirely on their statements, adding here and there particulars of interest from the writings of Brooke, Wallace, and others.

The Orang-Utan would rarely seem to exceed four feet in height, but the body is very bulky, measuring two thirds of the height in circumference.

The Orang-Utan is found only in Sumatra and Borneo, and is common in either of these islands — in both of which it occurs always in low, flat plains, never in the mountains. It loves the densest and most sombre of the forests, which extend from the seashore inland, and thus is found only in the eastern half of Sumatra, where alone such forests occur, though, occasionally, it strays over to the western side.

On the other hand it is generally distributed through

Borneo, except in the mountains, or where the population is dense. In favorable places the hunter may, by good fortune, see three or four in a day.

Except in the pairing time, the old males usually live by themselves. The old females and the immature males, on the other hand, are often met with in twos and threes; and the former occasionally have young with them, though the pregnant females usually separate themselves, and sometimes remain apart after they have given birth to their offspring. The young Orangs seem to remain unusually long under their mother's protection, probably in consequence of their slow growth. While climbing the mother always carries her young against her bosom, the young holding on by the mother's hair. At what time of life the Orang-Utan becomes capable of propagation, and how long the females go with young is unknown, but it is probable that they are not adult until they arrive at ten or fifteen years of age. A female which lived for five years at Batavia had not attained one-third the height of the wild females. It is probable that, after reaching adult years, they go on growing, though slowly, and that they live to forty or fifty years. The Dyaks tell of old Orangs which have

Head of Orang-Utan.

not only lost all their teeth, but which find it so troublesome to climb that they maintain themselves on windfalls and juicy herbage.

The Orang is sluggish, exhibiting none of that marvellous activity characteristic of the Gibbons. Hunger alone seems to stir him to exertion, and when it is stilled he relapes into repose. When the animal sits, it curves its back and bows its head, so as to look straight down on the ground; sometimes it holds on with its hands by a higher branch, sometimes lets them hang phlegmatically down by its side; and in these positions the Orang will remain for hours together, in the same spot, almost without stirring, and only now and then giving utterance to its deep, growling voice. By day he usually climbs from one tree-top to another, and only at night descends to the ground: and if then threatened with danger he seeks refuge among the underwood. When not hunted, he remains a long time in the same locality, and sometimes stops for many days on the same tree, a firm place among its branches serving him for a bed. It is rare for the Orang to pass the night in the summit of a large tree, probaby because it is too windy and cold there for him; but as soon as night draws on he descends from the height and seeks out a fit bed in the lower and darker part, or in the leafy top of a small tree, among which he prefers Nibong palms, Pandani, or one of those parasitic orchids which gave the primeval forests of Borneo so characteristic and striking an appearance. But whenever he determines to sleep, there he prepares himself a sort of nest; little boughs and leaves are drawn together round the selected spot, and bent cross-

wise over one another; while to make the bed soft, great leaves of ferns, of orchids, of *Pandanus fasciculatis*, *Nipa fruticians*, etc., are laid over them. Those which Müller saw, many of them being very fresh, were situated at a height of ten to twenty-five feet above the ground, and had a circumference, on the average, of two or three feet. Some were packed many inches thick with *pandanus* leaves; others were remarkable only for the cracked twigs, which, united in a common centre, formed a regular platform. "The rude *hut*," says Sir James Brooke, "which they are stated to build in the trees, would be more properly called a seat or nest, for it has no roof or cover of any sort. The facility with which they form this nest is curious, and I had an opportunity of seeing a wounded female weave the branches together and seat herself within a minute."

According to the Dyaks the Orang rarely leaves his bed before the sun is well above the horizon and has dissipated the mists. He gets up about nine, and goes to bed again about five; but sometimes not till late in the twilight. He lies sometimes on his back, or, by way of change, turns on one side or the other, drawing his limbs up to his body, and resting his head on his hand. When the night is cold, windy, or rainy, he usually covers his body with a heap of *pandanus nipa*, or fern leaves, like those of which his bed is made, and he is especially careful to wrap up his head in them. It is this habit of covering himself up which has probably led to the fable that the Orang builds huts in the trees.

Although the Orang resides mostly amid the boughs

of great trees during the daytime, he is very rarely seen squatting on a thick branch as other apes, and particularly the Gibbons, do. The Orang, on the contrary, confines himself to the slender leafy branches, so that he is seen right at the top of the trees, a mode of life which is closely related to the constitution of his hinder limbs, and especially to that of his seat. For this is provided with no callosites such as are possessed by many of the lower apes, and even by the Gibbons; and those bones of the pelvis, which are termed the ischia, and which form the solid framework of the surface on which the body rests in the sitting posture, are not expanded like those of the apes which possess callosities, but are more like those of man.

An Orang climbs so slowly and cautiously as, in this act, to resemble a man more than an ape, taking great care of his feet, so that injury of them seems to affect him far more than it does other apes. Unlike the Gibbons, whose forearms do the greater part of the work as they swing from branch to branch, the Orang never makes even the smallest jump. In climbing, he moves alternately one hand and one foot, or, after having laid fast hold with the hands, he draws up both feet together. In passing from one tree to another he always seeks out a place where the twigs of both come close together, or interlace. Even when closely pursued, his circumspection is amazing; he shakes the branches to see if they will bear him, and then bending an overhanging bough down by throwing his weight gradually along it, he makes a bridge from the tree he wishes to quit to the next.

On the ground the Orang always goes laboriously

and shakily on all fours. At starting he will run faster than a man, though he may soon be overtaken. The very long arms which, when he runs, are but little bent, raise the body of the Orang remarkably, so that he assumes much the posture of a very old man bent down by age, and making his way along by the help of a stick. In walking, the body is usually directed straight forward, unlike the other apes, which run more or less obliquely, except the Gibbons, who in these, as in so many other respects, depart remarkably from their fellows.

The Orang cannot put its feet flat on the ground, but is supported upon their outer edges, the heel resting more on the ground, while the curved toes partly rest upon the ground by the upper side of their first joint, the two outermost toes of each foot completely resting on this surface. The hands are held in the opposite manner, their inner edges serving as the chief support. The fingers are then bent out in such a manner that their foremost joints, especially those of the two innermost fingers, rest upon the ground by their upper sides, while the point of the free and straight thumb serves as an additional fulcrum.

The Orang never stands on its hind legs, and all the pictures representing it as so doing are as false as the assertion that it defends itself with sticks and the like.

The long arms are of especial use, not only in climbing, but in the gathering of food from boughs to which the animal could not trust his weight. Figs, blossoms, and young leaves of various kinds, constitute the chief nutriment of the Orang; but strips of bamboo two or

three feet long were found in the stomach of a male. They are not known to eat living animals.

Although, when taken young, the Orang-Utan soon becomes domesticated, and indeed seems to court human society; it is naturally a very wild and shy animal, though apparently sluggish and melancholy. The Dyaks affirm that when the old males are wounded with arrows only they will occasionally leave the trees and rush raging upon their enemies, whose sole safety lies in instant flight, as they are sure to be killed if caught.

But, though possessed of immense strength, it is rare for the Orang to attempt to defend itself, especially when attacked with firearms. On such occasions he endeavors to hide himself, or to escape along the topmost branches of the trees, breaking off and throwing down the boughs as he goes. When wounded he betakes himself to the highest attainable point of the tree, and emits a singular cry, consisting at first of high notes, which at length deepen into a low roar, not unlike that of a panther. While giving out the high notes the Orang thrusts out his lips into a funnel-shape; but in uttering the low notes he holds his mouth wide open, and at the same time the great throat bag, or laryngeal sac, becomes distended.

According to the Dyaks, the only animal the Orang measures his strength with is the crocodile, who occasionally seizes him on his visits to the water-side. But they say that the Orang is more than a match for his enemy, and beats him to death, or rips up his throat by pulling the jaws asunder!

Much of what has been here stated was probably

derived by Dr. Müller from the reports of his Dyak hunters; but a large male, four feet high, lived in captivity under his observation for a month, and receives a very bad character.

"He was a very wild beast," says Müller, "of prodigious strength, and false and wicked to the last degree. If any one approached he rose up slowly with a low growl, fixed his eyes in the direction in which he meant to make his attack, slowly passed his hand between the bars of his cage, and then, extending his long arm, gave a sudden grip — usually at the face." He never tried to bite (though Orangs will bite one another), his great weapons of offence and defence being his hands.

His intelligence was very great; and Müller remarks that, though the faculties of the Orang have been estimated too highly, yet Cuvier, had he seen this specimen, would not have considered its intelligence to be only a little higher than that of a dog.

His hearing was very acute, but the sense of vision seemed to be less perfect. The under lip was the great organ of touch, and played a very important part in drinking, being thrust out like a trough, so as either to catch the falling rain or to receive the contents of the half cocoanut shell full of water with which the Orang was supplied, and which, in drinking, he poured into the trough thus formed.

In Borneo, the Orang-Utan of the Malays goes by the name of "*Mias*" among the Dyaks, who distinguish several kinds as *Mias Pappan*, or *Zimo*, *Mias Kassu*, and *Mias Rambi*. Whether these are distinct species, however, or whether they are mere races, and how far

any of them are identical with the Sumatran Orang, as Mr. Wallace thinks the Mias Pappan to be, are problems which are at present undecided; and the variability of these great apes is so extensive that the settlement of the question is a matter of great difficulty. Of the form called "Mias Pappan," Mr. Wallace observes: "It is known by its large size, and by the lateral expansion of the face into fatty protuberances, or ridges, over the temporal muscles, which have been mistermed callosites, as they are perfectly soft, smooth, and flexible. Five of this form, measured by me, varied only from 4 feet 1 inch to 4 feet 2 inches in height, from the heel to the crown of the head, the girth of the body from 3 feet to 3 feet 7½ inches, and the extent of the outstretched arms from 7 feet 2 inches to 7 feet 6 inches; the width of the face from 10 to 13¼ inches. The color and length of the hair varied in different individuals, and in different parts of the same individual; some possessed a rudimentary nail on the great toe, others none at all; but they otherwise present no external differences on which to establish even varieties of a species.

"Yet, when we examine the crania of these individuals, we find remarkable differences of form, proportion, and dimension, no two being exactly alike. The slope of the profile, and the projection of the muzzle, together with the size of the cranium, offer differences as decided as those existing between the most strongly marked forms of the Caucasian and African crania in the human species. The orbits vary in width and height, the cranial ridge is either single or double, either much or little developed, and the zygomatic

aperture varies considerably in size. This variation in the proportions of the crania enables us satisfactorily to explain the marked difference presented by the single-crested and double-crested skulls, which have been thought to prove the existence of two large species of Orang. The external surface of the skull varies considerably in size, as do also the zygomatic aperture and the temporal muscle: but they bear no necessary relation to each other, a small muscle often existing with a large cranial surface, and vice versâ. Now those skulls which have the largest and strongest jaws, and the widest zygomatic aperture, have the muscles so large that they meet on the crown of the skull, and deposit the bony ridge which separates them, and which is the highest in that which has the smallest cranial surface. In those which combine a large surface with comparatively weak jaws, and small zygomatic aperture, the muscles, on each side, do not extend to the crown, a space of from 1 to 2 inches remaining between them, and along their margins small ridges are formed. Intermediate forms are found, in which the ridges meet only in the hinder part of the skull. The form and size of the ridges are therefore independent of age, being sometimes more strongly developed in the less aged animal. Professor Temminck states that the series of skulls in the Leyden Museum shows the same result."

Mr. Wallace observed two male adult Orangs (Mias Kassu of the Dyaks), however, so very different from any of these that he concludes them to be specially distinct; they were respectively 3 feet $8\frac{1}{2}$ inches and 3 feet $9\frac{1}{2}$ inches high, and possessed no sign of the cheek

excrescences, but otherwise resembled the larger kinds. The skull has no crest, but two bony ridges, $1\frac{3}{4}$ to 2 inches apart, as in the *Simia morio* of Professor Owen. The teeth, however, are immense, equalling or surpassing those of the other species. The females of both these kinds, according to Mr. Wallace, are devoid of excrescences, and resemble the smaller males, but are shorter by $1\frac{1}{2}$ to 3 inches, and their canine teeth are comparatively small, subtruncated and dilated at the base, as in the so-called *Simia morio*, which is, in all probability, the skull of a female of the same species as the smaller males. Both males and females of this smaller species are distinguishable, according to Mr. Wallace, by the comparatively large size of the middle incisors of the upper jaw.

So far as I am aware, no one has attempted to dispute the accuracy of the statements which I have just quoted regarding the habits of the two Asiatic man-like Apes; and if true, they must be admitted as evidence that such an ape—

1stly, May readily move along the ground in the erect, or semi-erect, position, and without direct support from its arms.

2dly, That it may possess an extremely loud voice—so loud as to be readily heard one or two miles.

3dly, That it may be capable of great viciousness and violence when irritated; and this is especially true of adult males.

4thly, That it may build a nest to sleep in.

Such being well-established facts respecting the Asiatic anthropoids, analogy alone might justify us in expecting the African species to offer similar peculiar-

ities, separately or combined; or, at any rate, would destroy the force of any attempted *à priori* argument against such direct testimony as might be adduced in favor of their existence. And if the organization of any of the African apes could be demonstrated to fit it better than either of its Asiatic allies for the erect position and for efficient attack, there would be still less reason for doubting its occasional adoption of the upright attitude, or of aggressive proceedings.

Head of Chimpanzee.

From the time of Tyson and Tulpius downward the habits of the young Chimpanzee in a state of captivity have been abundantly reported and commented upon. But trustworthy evidence as to the manners and customs of adult anthropoids of this species, in their native woods, was almost wanting up to the time of the publication of the paper by Dr. Savage, to which I have already referred, containing notes of the observations which he made, and of the information which he collected from sources which he considered trustworthy, while resident at Cape Palmas, at the north-western limit of the Bight of Benin.

The adult Chimpanzees, measured by Dr. Savage,

never exceeded, though the males may almost attain, five feet in height.

"When at rest, the sitting posture is that generally assumed. They are sometimes seen standing and walking, but when thus detected, they immediately take to all fours and flee from the presence of the observer. Such is their organization that they cannot stand erect, but lean forward. Hence they are seen, when standing, with the hands clasped over the occiput, or the lumbar region, which would seem necessary to balance or ease of posture.

"The toes of the adult are strongly flexed and turned inward, and cannot be perfectly straightened. In the attempt the skin gathers into thick folds on the back, showing that the full expansion of the foot, as is necessary in walking, is unnatural. The natural position is on all fours, the body anteriorly resting upon the knuckles. These are greatly enlarged, with the skin protuberant and thickened like the sole of the foot.

"They are expert climbers, as one would suppose from their organization. In their gambols they swing from limb to limb at a great distance, and leap with astonishing agility. It is not unusual to see the 'old folks' (in the language of an observer) sitting under a tree regaling themselves with fruit and friendly chat, while their 'children' are leaping around them, and swinging from tree to tree with boisterous merriment.

"As seen here, they cannot be called *gregarious*, seldom more than five, or ten at most, being found together. It has been said, on good authority, that they occasionally assemble in large numbers, in gambols. My informant asserts that he saw once not less than

fifty so engaged, hooting, screaming, and drumming with sticks upon old logs, which is done in the latter case with equal facility by the four extremities. They do not appear ever to act on the offensive, and, seldom, if ever, really on the defensive. When about to be captured, they resist by throwing their arms about their opponent, and attempting to draw him into contact with their teeth."

With respect to this last point Dr. Savage is very explicit in another place:

"*Biting* is their principal art of defence. I have seen one man who had been thus severely wounded in the feet.

"The strong development of the canine teeth in the adult would seem to indicate a carnivorous propensity; but in no state save that of domestication do they manifest it. At first they reject flesh, but easily acquire a fondness for it. The canines are early developed, and evidently designed to act the important part of weapons of defence. When in contact with man almost the first effort of the animal is — *to bite.*

"They avoid the abodes of men, and build their habitations in trees. Their construction is more that of *nests* than *huts*, as they have been erroneously termed by some naturalists. They generally build not far above the ground. Branches or twigs are bent, or partly broken, and crossed, and the whole supported by the body of a limb or a crotch. Sometimes a nest will be found near the *end* of a *strong leafy branch* twenty or thirty feet from the ground. One I have lately seen that could not be less than forty feet, and more probably it was fifty. But this is an unusual height.

"Their dwelling-place is not permanent, but changed in pursuit of food and solitude, according to the force of circumstances. We most often see them in elevated places; but this arises from the fact that the low grounds, being more favorable for the natives' rice-farms, are the oftener cleared, and hence are almost always wanting in suitable trees for their nests. . . . It is seldom that more than one or two nests are seen upon the same tree, or in the same neighborhood: five have been found, but it was an unusual circumstance." . . .

"They are very filthy in their habits. It is a tradition with the natives generally here that they were once members of their own tribe; that for their depraved habits they were expelled from all human society, and that, through an obstinate indulgence of their vile propensities, they have degenerated into their present state of organization. They are, however, eaten by them, and when cooked with the oil and pulp of the palm-nut considered a highly palatable morsel.

"They exhibit a remarkable degree of intelligence in their habits, and, on the part of the mother, much affection for their young. The second female described was upon a tree when first discovered, with her mate and two young ones (a male and a female). Her first impulse was to descend with great rapidity and make off into the thicket with her mate and female offspring. The young male remaining behind, she soon returned to the rescue. She ascended and took him in her arms, at which moment she was shot, the ball passing through the forearm of the young one, on the way to the heart of the mother. . . .

"In a recent case the mother, when discovered, remained upon the tree with her offspring, watching intently the movements of the hunter. As he took aim, she motioned with her hand, precisely in the manner of a human being, to have him desist and go away. When the wound has not proved instantly fatal, they have been known to stop the flow of blood by pressing with the hand upon the part, and when they did not succeed, to apply leaves and grass. . . . When shot, they give a sudden screech, not unlike that of a human being in sudden and acute distress.

"The ordinary voice of the Chimpanzee, however, is affirmed to be hoarse, guttural, and not very loud, somewhat like 'whoo-whoo.'"

The analogy of the Chimpanzee to the Orang, in its nest-building habit and in the mode of forming its nest, is exceedingly interesting, while, on the other hand, the activity of this ape, and its tendency to bite, are particulars in which it rather resembles the Gibbons. In extent of geographical range, again, the Chimpanzees — which are found from Sierra Leone to Congo — remind one of the Gibbons rather than of either of the other man-like Apes; and it seems not unlikely that, as is the case with the Gibbons, there may be several species spread over the geographical area of the genus.

The same excellent observer, from whom I have borrowed the preceding account of the habits of the adult Chimpanzee, published an account of the Gorilla, which has, in its most essential points, been confirmed by subsequent observers, and to which so very little has really been added, that, in justice to Dr. Savage, I give it almost in full:

"It should be borne in mind that my account is based upon the statements of the aborigines of that region (the Gaboon). In this connection it may also be proper for me to remark that, having been a missionary resident for several years, studying, from habitual intercourse, the African mind and character, I felt myself prepared to discriminate and decide upon the probability of their statements. Besides, being familiar with the history and habits of its interesting congener (*Troglodytes niger*, Geoff.), I was able to separate their accounts of the two animals, which, having the same locality and a similarity of habit, are confounded in the minds of the mass, especially as but few — such as traders to the interior, and huntsmen — have ever seen the animal in question.

"The tribe from which our knowledge of the animal is derived, and whose territory forms its habitat, is the *Mpongwe*, occupying both banks of the River Gaboon, from its mouth to some fifty or sixty miles upward. . . .

"If the word 'Pongo' be of African origin, it is probably a corruption of the word *Mpongwe*, the name of the tribe on the banks of the Gaboon, and hence applied to the region they inhabit. Their local name for the Chimpanzee is *Enché-eko*, as near as it can be Anglicized, from which the common term 'Jocko' probably comes. The *Mpongwe* apellation for its new congener is *Engé-ena*, prolonging the sound of the first vowel, and slightly sounding the second.

"The habitat of the *Engé-ena* is the interior of Lower Guinea, while that of the *Enché-eko* is nearer the seaboard.

"Its height is about five feet; it is disproportionately broad across the shoulders, thickly covered with coarse black hair, which is said to be similar in its arrangement to that of the *Enché-eko;* with age it becomes gray, which fact has given rise to the report that both animals are seen of different colors.

"Head. — The prominent features of the head are the great width and elongation of the face, the depth of the molar region, the branches of the lower jaw being very deep and extending far backward, and the comparative smallness of the cranial portion; the eyes are very large, and said to be like those of the *Enché-eko*, a bright hazel; nose broad and flat, slightly elevated toward the root; the muzzle broad, and prominent lips and chin, with scattered gray hairs; the under lip highly mobile, and capable of great elongation when the animal is enraged, then hanging over the chin; skin of the face and ears naked and of a dark-brown, approaching to black.

"The most remarkable feature of the head is a high ridge, or crest of hair, in the course of the sagittal suture, which meets posteriorly with a transverse ridge of the same, but less prominent, running round from the back of one ear to the other. The animal has the power of moving the scalp freely forward and back, and when enraged is said to contract it strongly over the brow, thus bringing down the hairy ridge and pointing the hair forward, so as to present an indescribably ferocious aspect.

"Neck short, thick, and hairy; chest and shoulders very broad, and said to be fully double the size of the *Enché-ekos;* arms very long, reaching some way below

THE GORILLA

the knee — the forearm much the shortest; hands very large, the thumbs much larger than the fingers. . . .

"The gait is shuffling; the motion of the body, which is never upright as in man, but bent forward, is somewhat rolling, or from side to side. The arms being longer than the Chimpanzee, it does not stoop as much in walking; like that animal, it makes progression by thrusting its arms forward, resting the hands on the ground, and then giving the body a half-jumping, half-swinging motion between them. In this act it is said not to flex the fingers, as does the Chimpanzee, resting on its knuckles, but to extend them, making a fulcrum of the hand. When it assumes the walking posture, to which it is said to be much inclined, it balances its huge body by flexing its arms upward.

"They live in bands, but are not so numerous as the Chimpanzees; the females generally exceed the other sex in number. My informants all agree in the assertion that but one adult male is seen in a band; that where the young males grow up a contest takes place for mastery, and the strongest, by killing and driving out the others, establishes himself as the head of the community."

Dr. Savage repudiates the stories about the Gorillas carrying off women and vanquishing elephants, and then adds:

"Their dwellings, if they may be so called, are similar to those of the Chimpanzee, consisting simply of a few sticks and leafy branches, supported by the crotches and limbs of trees; they afford no shelter, and are occupied only at night.

"They are exceedingly ferocious, and always offen-

sive in their habits, never running from man, as does the Chimpanzee. They are objects of terror to the natives, and are never encountered by them except on the defensive. The few that have been captured were killed by elephant-hunters and native traders, as they came suddenly upon them while passing through the forests.

"It is said that when the male is first seen he gives a terrific yell, that resounds far and wide through the forest, something like kh — ah! kh — ah! prolonged and shrill. His enormous jaws are widely opened at each expiration, his under-lip hangs over the chin, and the hairy ridge and scalp are contracted upon the brow, presenting an aspect of indescribable ferocity.

"The females and young, at the first cry, quickly disappear. He then approaches the enemy in great fury, pouring out his horrid cries in quick succession. The hunter awaits his approach with his gun extended; if his aim is not sure he permits the animal to grasp the barrel, and as he carries it to his mouth (which is his habit) he fires. Should the gun fail to go off, the barrel (that of the ordinary musket, which is thin), is crushed between his teeth and the encounter soon proves fatal to the hunter.

"In the wild state their habits are in general like those of the *Trogloytes niger*, building their nests loosely in trees, living on similar fruits, and changing their place of resort from force of circumstances."

Dr. Savage's observations were confirmed and supplemented by those of Mr. Ford, who communicated an interesting paper on the Gorilla to the Philadelphian Academy of Sciences, in 1852. With respect to the

geographical distribution of this greatest of all the man-like Apes, Mr. Ford remarks:

"This animal inhabits the range of mountains that traverse the interior of Guinea from the Cameroon in the north to Angola in the south, and about one hundred miles inland, and called by the geographers Crystal Mountains. The limit to which this animal extends, either north or south, I am unable to define. But that limit is doubtless some distance north of this river [Gaboon]. I was able to certify myself of this fact in a late excursion to the head-waters of the Mooney (Danger) River, which comes into the sea some sixty miles from this place. I was informed (credibly, I think), that they were numerous among the mountains in which that river rises, and far north of that.

"In the south, this species extends to the Congo River, as I am told by native traders who have visited the coast, between the Gaboon and that river. Beyond that, I am not informed. This animal is only found at a distance from the coast in most cases, and, according to my best information, approaches it nowhere so nearly as on the south side of this river, where they have been found within ten miles of the sea. This, however, is only of late occurrence. I am informed by some of the oldest Mpongwe men that formerly he was only found on the sources of the river, but that at present he may be found within half a day's walk of its mouth. Formerly he inhabited the mountainous ridge where Bushmen alone inhabited, but now he boldly approaches the Mpongwe plantations. This is doubtless the reason of the scarcity of information in years past, as the opportunities for receiving a

knowledge of the animal have not been wanting; traders having for one hundred years frequented this river, and specimens, such as have been brought here within a year, could not have been exhibited without having attracted the attention of the most stupid."

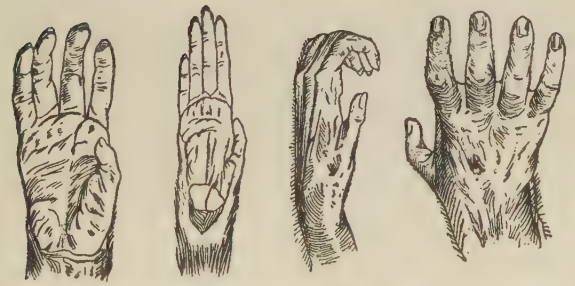
One specimen Mr. Ford examined weighed one hundred and seventy pounds, without the thoracic or pelvic viscera, and measured four feet four inches round the chest. This writer describes so minutely and graphically the onslaught of the Gorilla — though he does not for a moment pretend to have witnessed the scene — that I am tempted to give this part of his paper in full, for comparison with other narratives.

"He always rises to his feet when making an attack, though he approaches his antagonist in a stooping posture.

"Though he never lies in wait, yet, when he hears, sees, or scents a man, he immediately utters his characteristic cry, prepares for an attack, and always acts on the offensive. The cry he utters resembles a grunt more than a growl, and is similar to the cry of the Chimpanzee when irritated, but vastly louder. It is said to be audible at a great distance. His preparation consists in attending the females and young ones, by whom he is usually accompanied, to a little distance. He, however, soon returns with his crest erect and projecting forward, his nostrils dilated, and his underlip thrown down; at the same time uttering his characteristic yell, designed, it would seem, to terrify his antagonist. Instantly, unless he is disabled by a well-directed shot, he makes an onset, and, striking his antagonist with the palm of his hands, or seizing him

with a grasp from which there is no escape, he dashes him upon the ground, and lacerates him with his tusks.

"He is said to seize a musket, and instantly crush the barrel between his teeth. . . . This animal's savage nature is very well shown by the implacable desperation of a young one that was brought here. It was taken very young, and kept four months, and many means were used to tame it; but it was incorrigible, so that it bit me an hour before it died."



Hand of Gorilla, Orang, Gibbon, and Chimpanzee.

SOME STRANGE NURSERIES

(From Nature's Workshop.)

By GRANT ALLEN.

Sea-Horses.

YOU could hardly find a better rough test of relative development in the animal (or vegetable) world than the number of young produced and the care bestowed upon them. The fewer the offspring, the higher the type. Very low animals turn out thousands of eggs with reckless profusion; but they let them look after themselves, or be devoured by enemies, as chance will have it. The higher you go in the scale of being, the smaller the families, but the greater amount of pains expended upon the rearing and upbringing of the young. Large broods mean low organization; small broods imply higher types and more care in the nurture and education of the offspring. Primitive kinds produce eggs wholesale, on the off chance that some two or three among them may perhaps survive an infant mortality of ninety-nine per cent, so as to replace their parents. Advanced kinds produce half a dozen young, or less, but bring a large proportion of these on an average up to years of discretion.

Without taking into account insects and such other "small deer," — to quote Shakespeare's expression, — this fundamental principle of population will become at once apparent if we examine merely familiar instances of back-boned or vertebrate animals. The lowest vertebrates are clearly the fishes: and the true fishes have almost invariably gigantic families. A single cod, for example, is said to produce, roughly speaking, nine million eggs at a birth (I cannot pretend I have checked this calculation); but supposing they were only a million, and that one-tenth of those eggs alone ever came to maturity, there would still be a hundred thousand codfish in the sea this year for every pair that swam in it last year: and these would increase to a hundred thousand times that number next year; and so on, till in four or five years' time the whole sea would be but one solid mass of closely-packed cod-banks. We can see for ourselves that nothing of the sort actually occurs — practically speaking, there are about the same number of cod one year as another. In spite of this enormous birth-rate, therefore, the cod population is not increasing — it is at a standstill. What does that imply? Why, that taking one brood and one year with another, only a pair of cod, roughly speaking, survive to maturity out of each eight or nine million eggs. The mother cod lays its millions, in order that two may arrive at the period of spawning. All the rest get devoured as eggs, or snapped up as young fry, or else die of starvation, or are otherwise unaccounted for. It seems to us a wasteful way of replenishing the earth: but it is nature's way; we can only bow respectfully to her final decision.

Frogs and other amphibians stand higher in the scale of life than fish; they have acquired legs in place of fins, and lungs instead of gills; they can hop about on shore with perfect freedom. Now, frogs still produce a great deal of spawn, as every one knows: but the eggs in each brood are numbered in their case by hundreds, or at most by a thousand or two, not by millions as with many fishes. The spawn hatches out as a rule in ponds, and we have all seen the little black tadpoles crowding the edges of the water in such innumerable masses that one would suppose the frogs to be developed from them must cover the length and breadth of England. Yet what becomes of them all? Hundreds are destroyed in the early tadpole stage — eaten up or starved, or crowded out for want of air and space and water: a few alone survive or develop four legs, and absorb their tails and hop on shore as tiny froglins. Even then the massacre of the innocents continues. Only a tithe of those which succeeded in quitting their native pond ever return to it full grown, to spawn in due time, and become the parents of further generations.

Lizards and other reptiles make an obvious advance on the frog type; they lay relatively few eggs, but they begin to care for their young. The family is not here abandoned at birth, as among frogs, but is frequently tended and fed and overlooked by the mother. In birds we have a still higher development of the same marked parental tendency; only three or four eggs are laid each year, as a rule, and on these eggs the mother sits, while both parents feed the callow nestlings till such time as they are able to take care of

themselves and pick up their own living. Among mammals, which stand undoubtedly at the head of created nature, the lower types, like mice and rabbits, have frequent broods of many young at a time; but the more advanced groups, such as the horses, cows, deer, and elephants, have usually one foal or calf at a birth, and seldom produce more than a couple. Moreover, in all these higher cases alike, the young are fed with milk by the mother, and so spared the trouble of providing for themselves in their early days, like the young codfish or the baby tadpole. Starvation at the outset is reduced to a minimum.

It is interesting to note, too, that anticipations of higher types, so to speak, often occur among lower races. An animal here and there among the simpler forms hits upon some device essentially similar to that of some higher group with which it is really quite unrelated. For example, those who have read my account of the common earwig (given in the sixth chapter of "Flashlights on Nature") will recollect how that lowly insect sits on her eggs much as a hen does, and brings up her brood of callow grubs as if they were chickens. In much the same way, anticipations of the mammalian type occur pretty frequently among lower animals. Our commonest English lizard, for example, which frequents moors and sandhills, does not lay or deposit its eggs at all, but hatches them out in its own body, and so apparently brings them forth alive: while among snakes, the same habit occurs in the adder or viper. The very name *viper*, indeed, is a corruption of *vivipara*, the snake which produces living young. Still more closely do some birds resemble mammals in the

habit of secreting a sort of milk for the sustenance of their nestlings. Most people think the phrase "pigeon's milk" is much like the phrase "the horse-marines," a burlesque name for an absurd and impossible monstrosity. But it is nothing of the sort: it answers to a real fact in the economy of certain doves, which eat grain or seeds, grind and digest it in their own gizzards into a fine soft pulp or porridge, and then feed their young with it from their crops and beaks. This is thus a sort of bird-like imitation of milk. Only the cow or the goat takes grass or leaves, chews, swallows, and digests them, and manufactures from them in her own body that much more nutritive substance, milk, with which all mammals feed their infant offspring.

Now, after this rather long preamble, I am going to show you in this present article a few other examples of special care taken of the young in certain quarters where it might be least expected. Fish are not creatures from which we look for marked domestic virtues: yet we may find them there abundantly. Let us begin with that familiar friend of our childhood, the common English stickleback.

Which of us cannot look back in youth to the mysteries of the stickleback fisheries? Captains courageous, we sailed forth with bent pin and piece of thread, to woo the wily quarry with half an inch of chopped earthworm. For stickleback abound in every running stream and pond in England. They are beautiful little creatures, too, when you come to examine them, great favorites in the fresh-water aquarium; the male in particular is exquisitely colored, his hues growing brighter and his sheen more conspicuous at the pairing

season. There are many species of sticklebacks — in England we have three very different kinds — but all are alike in one point which gives them their common name, that is to say, in their aggressive and protective prickliness. They are armed against all comers. The dorsal fin is partly replaced in the whole family by strong spines or "stickles," which differ in number in the different species. One of our English sorts is a lover of salt water: he lives in the sea, especially off the Cornish coast, and has fifteen stickles or spines; on which account he is commonly known as the Fifteen-spined Stickleback; our other two sorts belong to fresher waters, and are known as the Ten-spined and the Three-spined respectively.

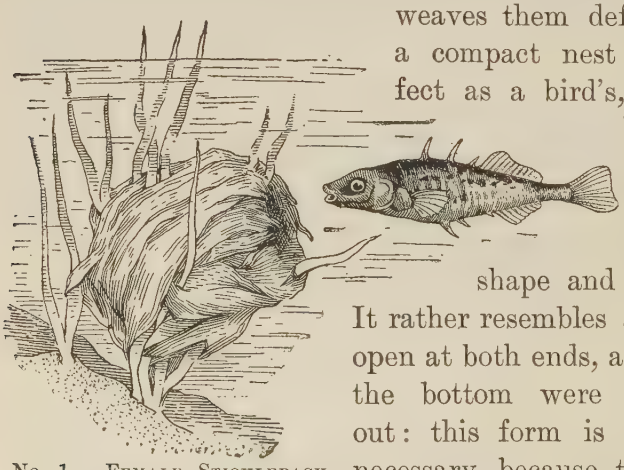
The special peculiarity of the male stickleback consists in the fact that he is, above all things, a model father. In his acute sense of parental responsibility he has few equals. When spring comes round, he first exhibits his consciousness of his coming charge by suddenly enduing himself in a glowing coat of many colors and of iridescent brilliancy. That is in order to charm the eyes of the prospective mate, or rather mates, for I may as well confess the sad truth at once that our amiable friend is a good parent but an abandoned polygamist. We all know that

> "In the spring a fuller crimson comes upon the robin's breast;
> In the spring the wanton lapwing gets himself another crest;
> In the spring a livelier iris changes on the burnish'd dove;
> In the spring a young man's fancy lightly turns to thoughts of love."

Not to be out of the fashion, therefore, the romantic stickleback does precisely the same thing as all these

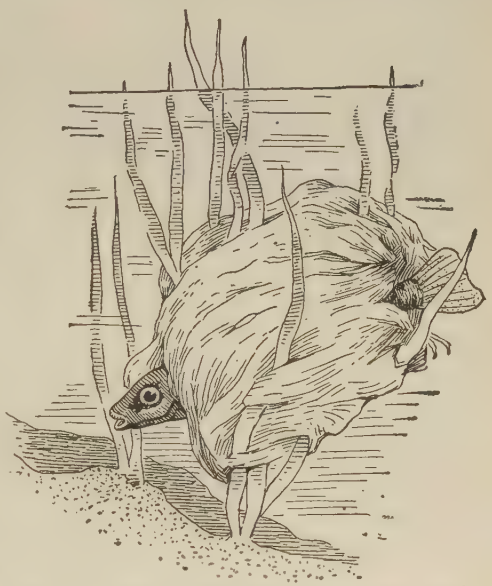
distinguished and poetical compeers. And he does it for the same reason, too; because he wants to get himself an appropriate partner. "There is a great deal of human nature in man," it has been said: I am always inclined to add, "And there is a great deal of human nature in plants and animals." The more we know of our dumb relations, the more closely do we realize the kinship between us. Fish in the spring are like young men at a fair — all eager for the attention of their prospective partners.

The first care of the male stickleback, when he has acquired his courting suit, is to build a suitable home for his future wives and children. So he picks up stems of grass and water-weeds with his mouth, and weaves them deftly into a compact nest as perfect as a bird's, though somewhat different in shape and pattern. It rather resembles a barrel, open at both ends, as though the bottom were knocked out: this form is rendered necessary because the eggs, when laid, have to be constantly aerated by passing a current of water through the nest as I shall describe hereafter. No. 1 shows us such a nest when completed, with the female stickleback loitering about undecided as to whether or



No. 1. Female Stickleback about to Enter Nest.

not she shall plunge and enter it. You will observe that the fabric is woven round a fixed support of some waving water-weeds; but the cunning little architect does not trust in this matter to his textile skill alone; he cements the straws and other materials together with a gummy mortar of mucous threads secreted for the purpose by his internal organs.



No. 2. Female Stickleback Laying Eggs in Nest.

As soon as the building operations are fully completed, the eager little householder sallies forth into his pond or brook in search of a mate who will come and stock his neatly-built home for him. At this stage of the proceedings, his wedding-garment becomes even more brilliant and glancing than ever; he gleams in silver and changeful gems; when he finds his lady-love, he dances round her, "mad with excitement," as Darwin well phrased it, looking his handsomest and best with his lustrous colours glistening like an opal. If she will listen to his suit, he grows wild with delight, and coaxes her into the nest with most affectionate endearments. In No. 2, as you perceive, the

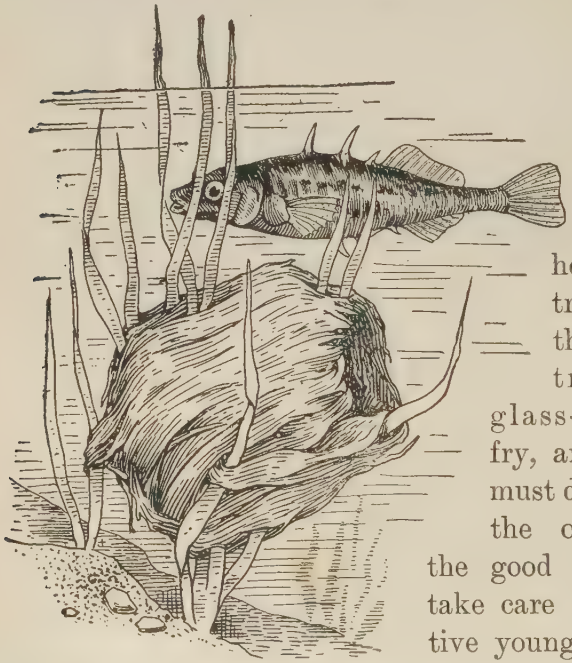
mate of his choice has been induced to enter, and is laying her eggs in the dainty home his care has provided for her. The father fish, meanwhile dances and capers around, in a *pas de triomphe* at the success of his endeavors.

One wife, however, does not suffice to fill the nest with eggs; and the stickleback is a firm believer in the advantages of large families. So, as soon as his first mate has laid all her spawn, he sets out once more in search of another. Thus he goes on until the home is quite full of eggs, bringing back one wife after another, in proportion to his success in wooing and fighting. For, like almost all polygamists, your stickleback is a terrible fighter. The males join wager of battle with one another for possession of their mates; in their fierce duels they make fearful use of the formidable spines on their backs, sometimes entirely ripping up and cutting to pieces their ill-fated adversary. The spines thus answer to the spurs of the gamecock or the antlers of the deer; they are masculine weapons in the struggle for mates. Indeed, you may take it for granted that brilliant colors and decorative adjuncts in animals almost invariably go with irascible tempers, pugnacious habits, and the practice of fighting for the possession of the harem. The consequence is, with the sticklebacks, that many males get killed during the struggle for supremacy, so that the survivors wed half a dozen wives each, like little Turks that they are in their watery seraglios. Only the most beautiful and courageous fish succeed in gaining a harem of their own: and thus the wager of battle tells in the end for the advantage of the race, by eliminating the maimed,

the ugly, and the cowardly, and encouraging the strong, the handsome, the enterprising, and the valiant. This is nature's way of preventing degeneracy.

In No. 3 the nest is seen full of eggs, and the excellent father now comes out in his best light as their guardian and protector. He watches over them with ceaseless care, freeing them from parasites, and warding off the attacks of would-be enemies who desire to devour them, even though the intruder be several times his own size. The spines on his back here stand him once more in good stead: for small as he is, the stickleback is not an antagonist to be lightly despised: he can inflict a wound which a perch or a trout knows how to estimate at its full value. But that is not all the good parent's duty. He takes the eggs out of the nest every now and then with his snout, airs them a little in the fresh water outside, and then replaces and rearranges them, so that all may get a fair share of oxygen and may hatch out about simultaneously. It is this question of oxygen, indeed, which gives the father fish all the greatest trouble. That necessary of life is dissolved in water in very small quantities; and it is absolutely needed by every egg in order to enable it to undergo those vital changes which we know as hatching. To keep up a due supply of oxygen, therefore, the father stickleback ungrudgingly devotes laborious days in poising himself delicately just above the nest, as you see in No. 3, and fanning the eggs with his fins and tail, so as to set up a constant current of water through the centre of the barrel. He sits upon the eggs just as truly as a hen does; only, he sits upon them, not for warmth, but for aeration.

For weeks together this exemplary parent continues his monotonous task, ventilating the spawn many times every day, till the time comes for hatching. It takes about a month for the eggs to develop: and then the proud father's position grows more arduous than ever. He has to rock a thousand cradles at once, so to speak, and to pacify a thousand crying babies. On the one hand, enemies hover about, trying to eat the tender transparent glass-like little fry, and these he must drive off: on the other hand, the good nurse must take care that the active young fish do not stray far from the nest, and so expose themselves prematurely to the manifold dangers of the outer world. Till they are big enough to take care of themselves, he watches with incessant vigilance over their safety; as soon as they can go forth with tolerable security upon the world of their brook or pond, he takes a last well-merited holiday.



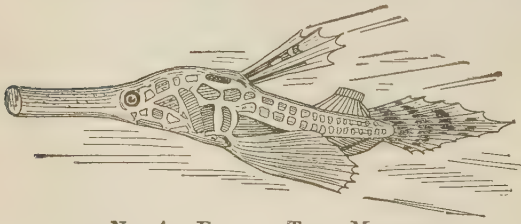
No. 3. Male Stickleback Watching Eggs in Nest.

It is not surprising under these circumstances to learn that sticklebacks are successful and increasing animals. Their numbers are enormous, wherever they get a fair chance in life, because they multiply rapidly up to the extreme limit of the means of subsistence, and develop as fast as food remains for them. There the inexorable Malthusian law at last steps in: when there is not food enough for all some must starve; that is the long and the short of the great population question. But while provender is forthcoming they increase gayly. Sticklebacks live mainly on the spawn of other fish, though they are so careful of their own, and they are therefore naturally hated by trout-preservers and owners of fisheries in general. Thousands and thousands are caught each year; in some places, indeed, they are so numerous that they are used as manure. It is their numbers, of course, that make them formidable; they are the locusts of the streams, well armed and pugnacious, and provided with most remarkable parental instincts of a protective character, which enables them to fill up all vacancies in their ranks as fast as they occur with astonishing promptitude.

To those whose acquaintance with fish is mainly culinary, it may seem odd to hear that the father stickleback alone takes part in the care of the nursery. But this is the rule among the whole class of fish; wherever the young are tended, it is almost always the father, not the mother, who undertakes the duty of incubation. Only two instances occur where the female fish assumes maternal functions towards her young; about these I shall have more to say a little later on. We must remember that rep-

tiles, birds, and mammals are in all probability descended from fish as ancestors, and it is therefore clear that the habit of handing over the care of the young to the female alone belongs to the higher grades of vertebrates — in other words, is of later origin. We need not be astonished, therefore, to find that in many cases among birds and other advanced vertebrates a partial reversion to the earlier habit not infrequently takes place. With doves, for example, the cock and hen birds sit equally on the eggs, taking turns about at the nest; and as for the ostriches, the male bird there does most of the incubation, for he accepts the whole of the night duty, and also assists at intervals during the daytime. There are numerous other cases where the father bird shares the tasks of the nursery at least equally with the mother. I will glance first, however, at one of the rare exceptions among fish where the main duty does not devolve on the devoted father.

In No. 4 we have an illustration of the tube-mouth or Solenostoma, one of the two known kinds of fish in which the female shows a sense of her position as a mother. The tube-mouth, as you can see at a glance, is a close relation of our old friend the sea-horse, whose disguised and undisguised forms in Australia and the Mediterranean we have already observed when dealing with the question of animal masqueraders. Solenostoma is a native of the Indian Ocean, from

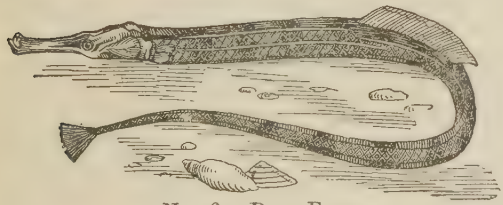


No. 4. Female Tube-Mouth.

Zanzibar to China. In the male, the lower pair of fins are separate, as is usual among fish; but in the female, represented in the accompanying sketch, they are lightly joined at the edge, so as to form a sort of pouch like a kangaroo's, in which the eggs are deposited after being laid, and thus carried about in the mother's safe keeping. No. 5 shows the arrangement of this pouch in detail, with the eggs inside it. The mother Solenostoma not only takes charge of the spawn while it is hatching in this receptacle, but also looks after the young fry, like the father stickleback, till they are of an age to go off on their own account in quest of adventures. The most frequent adventure that happens to them on the way is, of course, being eaten.

No. 5. Pouch of Tube-Mouth.

The common English pipe-fish is a good example of the other and much more usual case in which the father alone is actuated by a proper sense of parental responsibility. The pipe-fish, indeed, might almost be described as a pure and blameless rate-payer. No. 6 shows you the outer form of this familiar creature, whom you will recognize at a glance as still more nearly allied to the sea-horses than even the tube-mouth. Pipe-fishes are timid and skulking creatures. Like their horse-headed relations, they lurk for the most



No. 6. Pipe-Fish.

part among sea-weed for protection, and being but poor swimmers, never venture far from the covering shelter of their native thicket. But the curious part of them is that in this family the father fish is provided with a pouch even more perfect than that of the female tube-mouth, and that he himself, not his mate takes sole charge of the young, incubates them in his sack, and escorts them about for some time after hatching. The pouch, which is more fully represented in No. 7, is formed by a loose fold of skin arising from either side of the creature. In the illustration this fold is partly withdrawn, so as to show the young pipe-fish within their safe retreat after hatching out. It is said, I know not how truly, that the young fry will stroll out for an occasional swim on their own account, but will return at any threat of danger to their father's bosom, for a considerable time after the first hatching. This is just like what one knows of kangaroos and many other pouched mammals, where the mother's pouch becomes a sort of nursery, or place of refuge, to which the little ones return for warmth or safety after every excursion.

No. 7. Pouch of Pipe-Fish.

The sea-horses and many other fish have similar pouches; but, oddly enough, in every case it is the male fish which bears it, and which undertakes the arduous duty of nurse for his infant offspring.

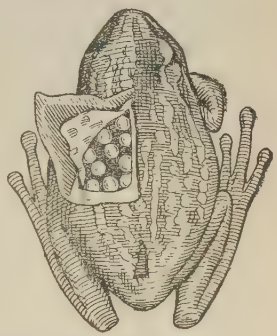
A few female fish, on the other hand, even hatch the eggs within their own bodies, and so apparently bring forth their young alive, like the English lizard among reptiles. This, however, is far from a common case: indeed, in an immense number of instances, neither parent pays the slightest attention to the eggs after they are once laid and got rid of: the spawn is left to lie on the bottom and be eaten or spared as chance directs, while the young fry have to take care of themselves, without the aid of parental advice and education. But exceptions occur where both parents show signs of realizing the responsibilities of their position. In some little South American river fish, for instance, the father and mother together build a nest of dead leaves for the spawn, and watch over it in unison until the young are hatched. This case is exactly analogous to that of the doves among birds: I may add that wherever such instances occur they always seem to be accompanied by a markedly gentle and affectionate nature. Brilliantly-coloured fighting polygamous fishes are fierce and cruel: monogamous and faithful animals are seldom bright-hued, but they mate for life and are usually remarkable for their domestic felicity. The doves and love-birds are familiar instances.

Frogs are very closely allied to fish: indeed, one may almost say that every frog begins life as a fish, limbless, gill-bearing, and aquatic, and ends it as something very like a reptile, four-legged, lung-bearing, and more or less terrestrial. For the tadpole is practically in all essentials a fish. It is not odd, therefore, to find that certain frogs reproduce, in a very marked manner, the fatherly traits of their fish-like ancestors. There

is a common kind of frog in France, Belgium, and Switzerland, which does not extend to England, but which closely recalls the habits of the stickleback and the pipe-fish. Among these eminently moral amphibians, it is the father, not the mother, who takes entire charge of the family. The female lays her spawn in the shape of long strings or rolls, looking at first sight like slimy necklaces. I have seen them as much as a couple of yards long, lying loose on the grass where the frog lays them. As soon as she has deposited them, however, the father frog hops up, twists the garlands dexterously in loose festoons round his legs and thighs, and then retires with his precious burden to some hole in the bank of his native pond, where he lurks in seclusion till the eggs develop. Frogs do not need frequent doses of food — their meals are often few and far between — and during the six or eight weeks that the eggs take to mature the father probably eats very little, though he may possibly sally forth at night, unobserved, in search of provender. At the end of that time the devoted parent, foreseeing developments, takes to the water once more, so that the tadpoles may be hatched in their proper element. I may add that this frog is a great musician in the breeding season, but that as soon as the tadpoles are hatched out he loses his voice entirely, and does not recover his manly croak till the succeeding spring. This is also the case with the song of many birds, the crest of the newt, the plumes of certain highly-decorated trogons and nightjars, and, roughly speaking, the decorative and attractive features of the male sex in general. Such features are given them

during the mating period as allurements for their consorts: they disappear, for the time at least, like a ball-dress after a ball, as soon as no immediate use can any longer be made of them.

Some American tree-frogs, on the other hand, imitate rather the motherly Solenostoma than the fatherly instincts of the pipe-fish or the stickleback. These pretty little creatures have a pouch like the kangaroo, but in their case (as in the kangaroo's) it is the female who bears it. Within this safe receptacle the eggs are placed by the male, who pushes them in with his hind feet; and they not only undergo their hatching in the pouch, but also pass through their whole tadpole development in the same place. Owing to the care which is thus extended to the eggs and young, these advanced tree-frogs are enabled to lay only about a dozen to fifteen eggs at a time, instead of the countless hundreds often produced by many of their relations.

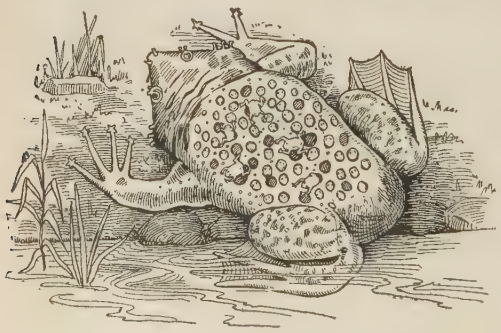


Pouched Frog.

Tree-frogs have, of course, in most circumstances much greater difficulty in getting at water than pond-frogs; and this is especially true in certain tropical or desert districts. Hence most of the frogs which inhabit such regions have had to find out or invent some ingenious plan for passing through the tadpole stage with a minimum of moisture. The devices they have hit upon are very curious. Some of them make use of the little pools collected at the bases of huge tropical leaf-stalks, like those of the banana plant; others dis-

pense with the aid of water altogether, and glue their new-laid eggs to their own backs, where the fry pass through the tadpole stage with the slimy mucus which surrounds them. Nature always discovers such cunning schemes to get over apparent difficulties in her way: and the tree-frogs have solved the problem for themselves in half a dozen manners in different localities. Oddest of all, perhaps, is the dodge invented by "Darwin's frog," a Chilean species, in which the male swallows the eggs as soon as laid, and gulps them into the throat-pouch beneath his capacious neck: there they hatch out and pass through their tadpole stage: and when at last they arrive at frogly maturity, they escape into the world through the mouth of their father.

The Surinam toad, represented in No. 8, is also the possessor of one of the strangest nurseries known to science. It lives in the dense tropical forests of Guiana and Brazil, and is a true water-haunter. But at the breeding season the female undergoes a curious change of integument. The skin on her back grows pulpy, soft, and jelly-like. She lays her eggs in the water: but as soon as she has laid them, her lord and master plasters them on to her impressionable back with his feet, so as to secure them from all assaults of enemies.



No. 8. The Surinam Toad.

Every egg is pressed separately into a bed of the soft skin, which soon closes over it automatically, thus burying each in a little cell or niche, where it undergoes its further development. The tadpoles pass through their larval stage within the cell, and then hop out, in the four-legged condition. As soon as they have gone off to shift for themselves, the mother toad finds herself with a ragged and honeycombed skin, which must be very uncomfortable. So she rubs the remnant of it off against stones or the bark of trees, and re-develops a similar back afresh at the next breeding season.

Almost never do we find a device in nature which occurs once only. The unique hardly exists : nature is a great copyist. At least two animals of wholly unlike kinds are all but sure to hit independently upon the self-same mechanism. So it is not surprising to learn that a cat-fish has invented an exactly similar mode of carrying its young to that adopted by the Surinam toad : only, here it is on the under surface, not the upper one, that the spawn is plastered. The eggs of this cat-fish, whose scientific name is Aspredo, are pressed into the skin below the body, and so borne about by the mother till they hatch. This is the second instance of which I spoke above, where the female fish herself assumes the care of her offspring, instead of leaving it entirely to her excellent partner.

Higher up in the scale of life we get many instances which show various stages in the same progressive development towards greater care for the safety and education of the young. Among the larger lizards, for example, a distinct advance may be traced between the comparatively uncivilized American alligator and his

near ally, the much more cultivated African crocodile. On the banks of the Mississippi, the alligator lays a hundred eggs or thereabouts, which she deposits in a nest near the water's edge, and then covers them up with leaves and other decaying vegetable matter. The fermentation of these leaves produces heat and so does for the alligator's eggs what sitting does for those of hens and other birds: the mother deputes her maternal functions, so to speak, to a festering heap of decomposing plant-refuse. Nevertheless, she loiters about all the time, like Miriam round the ark which contained Moses, to see what happens; and when the eggs hatch out, she leads her little ones down to the river, and there makes alligators of them. This is a simple and relatively low stage in the nursery arrangements of the big lizards.

The African crocodile, on the other hand, goes a stage higher. It lays only about thirty eggs, but these it buries in warm sand, and then lies on top of them at night, both to protect them from attack and to keep them warm during the cooler hours. In short, it sits upon them. When the young crocodiles within the eggs are ready to hatch, they utter an acute cry. The mother then digs down to the eggs, and lays them freely on the surface, so that the little reptiles may have space to work their way out unimpeded. This they do by biting at the shell with a specially developed tooth; at the end of two hours' nibbling they are free, and are led down to the water by their affectionate parent. In these two cases we see the beginnings of the instinct of hatching, which in birds, the next in order in the scale of being, has become almost universal.

I say *almost* universal, because even among birds there are a few kinds which have not to this day progressed beyond the alligator level. Australia is the happy hunting-ground of the zoölogist in search of antiquated forms, elsewhere extinct, and several Australian birds, such as the brush-turkeys, still treat their eggs essentially on the alligator method. The cock birds heap up huge mounds of earth and decaying vegetable matter, as much as would represent several cartloads of mould; and in this natural hot-bed the hens lay their eggs, burying each separately with a good stock of leaves around it. The heat of the sun and the fermenting mould hatch them out between them; to expedite the process, the birds uncover the eggs during the warmer part of the day, expose them to the sun, and bury them again in the hot-beds towards evening. Several intermediate steps may also be found between this early stage of communal nesting by proxy and the true hatching instinct; a good one is supplied by the ostrich, which partially buries its eggs in hot sand, but sits on them at intervals, both father and mother birds taking shares by turn in the duties of incubation.

The vast subject which I have thus lightly skimmed is not without interest, again, from its human implications. Savages as a rule produce enormous families; but then, the infant mortality in savage tribes is proportionally great. Among civilized races, families are smaller, and deaths in infancy are far less numerous. The higher the class or the natural grade of a stock, the larger as a rule the proportion of children safely reared to the adult age. The goal towards which

humanity is slowly moving would thus seem to be one where families in most cases will be relatively small — perhaps not more on an average than three to a household — but where most or all of the children brought into the world will be safely reared to full maturity. This is already becoming the rule in certain favored ranks of European society.

Tadpoles and Young Frog.

HOW ANIMALS SPEND THE WINTER

(From Gleanings from Nature.)[1]

By W. S. BLATCHLEY.

A Cocoon.

ONE of the greatest problems which each of the living forms about us has had to solve, during the years of its existence on earth, is how best to perpetuate its kind during that cold season which once each year, in our temperate zone, is bound to come. Many are the solutions to this problem. Each form of life has, as it were, solved it best to suit its own peculiar case, and to the earnest student of Nature there is nothing more interesting than to pry into these solutions and note how varied, strange, and wonderful they are.

To fully appreciate some of the facts mentioned below it must be borne in mind that there is no such thing as "spontaneous generation" of life. Every cell is the offspring of a pre-existing cell. Nothing but a living thing can produce a living thing.

[1] "Popular Science Monthly," February, 1897. Copyright by William Stanley Blatchley, 1899.

Hence every weed that next season will spring up and provoke the farmer's ire, and every insect which will then make life almost intolerable for man or beast, exists throughout the winter in some form. . . .

Beginning with the earth-worms and their kindred, we find that at the approach of winter they burrow deep down where the icy breath of the frost never reaches, and there they live, during the cold season, a life of comparative quiet. That they are exceedingly sensitive to warmth, however, may be proven by the fact that when a warm rain comes some night in February or March, thawing out the crust of the earth, the next morning reveals in our dooryards the mouths of hundreds of the pits or burrows of these primitive tillers of the soil, each surrounded by a little pile of pellets, the castings of the active artisans of the pits during the night before.

If we will get up before dawn on such a morning we can find the worms crawling actively about over the surface of the ground, but when the first signs of day appear they seek once more their protective burrows, and only an occasional belated individual serves as a breakfast for the early birds.

The eyes of these lowly creatures are not visible, and consist of single special cells scattered among the epidermal cells of the skin, and connected by means of a sensory nerve fibre with a little bunch of nervous matter in the body. Such a simple visual apparatus serves them only in distinguishing light from darkness, but this to them is most important knowledge, as it enables them to avoid the surface of the earth by day, when their worst enemies, the birds, are in active search for them.

The fresh-water mussels and snails and the crayfish burrow deep into the mud and silt at the bottom of ponds and streams where they lie motionless during the winter. The land snails, in late autumn, crawl beneath logs, and, burrowing deep into the soft mould, they withdraw far into their shells. Then each one forms with a mucous secretion two thin transparent membranes, one across the opening of the shell and one a little farther within, thus making the interior of the shell perfectly air-tight. There for five or six months he sleeps, free from the pangs of hunger and the blasts of winter, and when the balmy breezes of spring blow up from the south he breaks down and devours the protecting membrane and goes forth with his home on his back to seek fresh leaves for food and to find for himself a mate.

Next in the scale come the insects, which comprise four-fifths of all existing animals, and each one of the mighty horde seen in summer has passed the winter in some form. One must look for them in strange places and under many disguises; for they cannot migrate, as do the majority of the birds, nor can they live an active life while the source of their food supply, the plants, are inactive.

The majority of those insects which in May or June will be found feeding on the buds or leaves of our trees, or crawling worm-like over the grass of our lawns, or burrowing beneath the roots of our garden plants, are represented in the winter by the eggs alone. These eggs are deposited in autumn by the mother insect, on or near the object destined to furnish the young, or larvæ, their food. Each egg corre-

sponds to a seed of one of our annual plants; being, like it, but a form of life so fashioned and fitted as to withstand for a long period intense cold; the mother insect, like the summer form of the plant, succumbing to the first severe frost.

Thus myriads of the eggs of grasshoppers are in the early autumn deposited in the ground, in compact masses of forty to sixty each. About mid-April they begin to hatch, and the sprightly little insects, devoid of wings, but otherwise like their parents, begin their life-work of changing grass into flesh.

A comparatively small number of insects pass the winter in the larval or active stage of the young. Of these, perhaps the best known is the brown "woolly worm" or "hedgehog caterpillar," as it is familiarly called. It is thickly covered with stiff black hairs on each end, and with reddish hairs on the middle of the body. These hairs appear to be evenly and closely shorn, so as to give the animal a velvety look; and as they have a certain degree of elasticity, and the caterpillar curls up at the slightest touch, it generally manages to slip away when taken into the hand. Beneath loose bark, boards, rails, and stones, this caterpillar may be found in mid-winter, coiled up and apparently lifeless. On the first bright, sunny days of spring it may be seen crawling rapidly over the ground, seeking the earliest vegetation which will furnish it a literal "breakfast." In April

Hedgehog Caterpillar.

or May the chrysalis, surrounded by a loose cocoon formed of the hairs of the body interwoven with coarse silk, may be found in situations similar to those in which the larva passed the winter. From this, the perfect insect, the Isabella tiger moth, *Pyrrharctia isabella* Smith, emerges about the last of June. It is a medium sized moth, dull orange in color, with three rows of small black spots on the body, and some scattered spots of the same color on the wings.

By breaking open rotten logs one can find in mid-winter the grubs or larvæ of many of the wood-boring beetles, and, beneath logs and stones near the margins of ponds and brooks, hordes of the maggots or larvæ of certain kinds of flies may often be found huddled together in great masses. The larvæ of a few butterflies also live over winter beneath chips or bunches of leaves near the roots of their food plant, or in webs of their own construction, which are woven on the stems close to the buds, whose expanding leaves will furnish them their first meal in spring.

Many insects pass the winter in the quiescent or pupal stage; a state exceedingly well fitted for hibernating, requiring as it does, no food, and giving plenty of time for the marvellous changes which are then undergone. Some of these pupæ are enclosed in dense silken cocoons, which are bound to the twigs of the plants upon which the larvæ feed, and thus they swing securely in their silken hammocks through all the storms of winter. Perhaps the most common of these is that of the brown Cecropian moth, *Attacus cecropia* L., the large oval cocoon of which is a conspicuous object in the winter on the twigs of our common shade

and fruit trees. Many other pupæ may be found beneath logs or on the under side of bark, and usually have the chrysalis surrounded by a thin covering of hairs, which are rather loosely arranged. A number pass the cold season in the earth with no protective covering whatever. Among these is a large brown chrysa-

Chrysalis of Tomato Worm.

lis with a long tongue case bent over so as to resemble the handle of a jug. Every farm boy has ploughed or spaded it up in the spring, and is it but the pupa of a large sphinx moth, *Protoparce celeus* Hub., the larva of which is the great green worm, with a "horn on its tail," so common on tomato plants in the late summer.

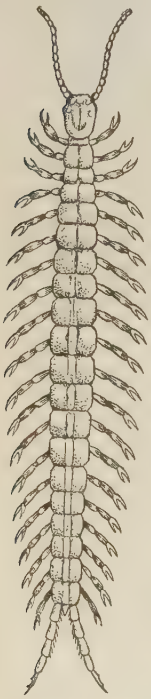
Each of the winter forms of insects above mentioned can withstand long and severe cold weather — in fact, may be frozen solid for weeks and retain life and vigor, both of which are shown when warm weather and food appear again. Indeed, it is not an unusually cold winter, but one of successive thawings and freezings, which is most destructive to insect life. A mild winter encourages the growth of mould which attacks the hibernating larvæ and pupæ as soon as, from excess of rain or humidity, they become sickly; and it also permits the continued activity of insectivorus mammals and birds. Thus, moles, shrews, and field mice, instead of burying themselves deeply in the ground, run about

freely during an open winter and destroy enormous numbers of pupæ; while such birds as the woodpeckers, titmice, and chickadees are constantly on the alert, and searching in every crevice and cranny of fence and bark of tree for the hibernating larvæ.

Of the creeping, wingless creatures, which can ever be found beneath rocks, rails, chunks, and especially beneath those old decaying logs which are half buried in the rich vegetable mould, the myriapods, or "thousand-legs," deserve more than a passing notice. They are typical examples of that great branch of the animal kingdom known as *arthropods*, which comprises all insects and crustaceans. Each arthropod has the body composed of rings placed end to end and bearing jointed appendages, and in the myriapods each ring and its appendages can be plainly seen; whereas in the higher forms of the branch many of the rings are so combined as to be very difficult to distinguish.

Full forty kinds of myriapods occur in any area comprising one hundred square miles in the eastern United States. About twenty-five of them go by the general name of "thousand-legs" or millipedes, as each has from forty to fifty-five cylindrical rings in the body, and two pairs of legs to each ring. The other fifteen belong to the "centipede" group, the body consisting of about sixteen flattened segments, or rings, each bearing a single pair of legs. When disturbed, the "thousand-legs" generally coils up and remains motionless, shamming death, or "playing possum," as it is popularly put, as a means of defence; while the centipede scampers hurriedly away and endeavors to hide beneath leaf, chip, or other object.

All those found in the Northern States are perfectly harmless, the true centipede, whose bite is reputed much more venomous than it really is, being found only in the South. True, some of the centipede group can pinch rather sharply with their beetle-like jaws; and one, our largest and most common species, a brownish red fellow about three inches long and without eyes, can even draw blood if its jaws happen to strike a tender place. When handled it always tries to bite, perhaps out of revenge for the abominably long Latin name given it by its describer. In fact the name is longer than the animal itself — *Sco-lo-po-cryp-tops sex-spi-no-sus* (Say) — being its cognomen in full. With such a handle attached to it, who can blame it for attempting to bite? Yet, to the scientist up on his Latin, each part of the above name bears a definite and tangible meaning. All the myriapods found in the woods and fields feed upon decaying vegetation, such as leaves, stems of weeds, and rotten wood, and in winter three or four species can usually be found within or beneath every decaying log or stump. One species with very long legs, *Scutigera forceps* (Raf.), is often found in damp houses or in cellars. It is sometimes called the "wall-sweeper," on account of its rapid ungainly gait, and is even reputed to prey upon cockroaches and other household pests.



CENTIPEDE.

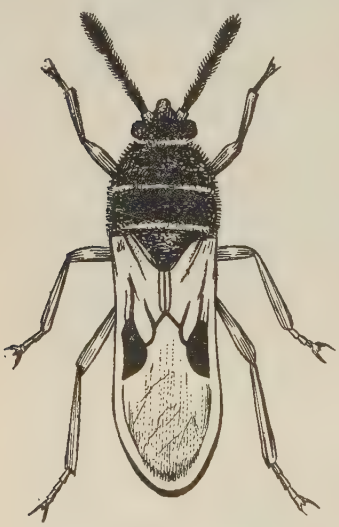
Spiders, which do not undergo such changes as do

most of the common, six-footed insects, winter either as eggs or in the mature form. The members of the "sedentary" or web-spinning group, as a rule, form nests in late autumn, in each of which are deposited from fifty to eighty eggs, which survive the winter and hatch in the spring, as soon as the food supply of gnats, flies, and mosquitoes appear. The different forms of spiders' nests are very interesting objects of study. Some are those close-spun, flat, button-shaped objects, about half an inch in diameter, which are so common in winter on the under side of bark, chunks and flat rocks. Others are balloon-shaped and attached to weeds. Within the latter the young spiders often hatch in early winter, make their first meal off their empty egg cases, and then begin a struggle for existence, the stronger preying upon the weaker until the south winds blow again, when they emerge and scatter far and wide in search of more nutritious sustenance.

The "wandering" spiders never spin webs, but run actively about and pounce upon their prey with a tiger-like spring. Six or eight of the larger species of this group winter in the mature form beneath logs and chunks, being often frozen solid during cold weather, but thawing out as healthy as ever when the temperature rises. Retiring beneath the loose-fitting bark of hickory or maple trees, a number of the smaller tube-weaving spiders construct about themselves a protecting web of many layers of the finest silk. Within this snug retreat they lie from November until April — a handsome, small, black fellow, with green jaws and two orange spots on his abdomen, being the most

common species found motionless within this seeming shroud of silk on a day in mid-winter.

In any Northern State as many as four hundred different kinds of the six-footed or true insects, in the winged or adult stage, may be taken in winter by any one who is so disposed, and knows where to search for them. Among the *Orthoptera*, the "grouse grasshoppers" live during the cold season beneath the loose bark of logs, or beneath the bottom rails of the old Virginia worm fences. From these retreats every warm, sunny day tempts them forth in numbers. On such occasions the earth seems to swarm with them, as they leap before the intruder, their hard bodies striking the dead leaves with a sound similar to that produced by falling hail. The common field cricket belongs also to the *Orthoptera*, and the young of various sizes winter under rails and logs, bidding defiance to Jack Frost from within a little burrow or pit beneath the protecting shelter.

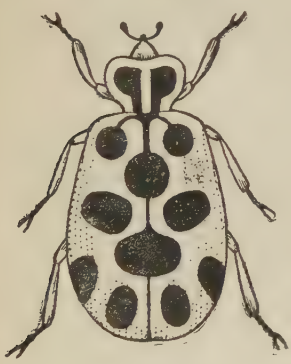


Chinch Bug.

The true bugs, or *Hemiptera*, hibernate in similar places; squash bugs, chinch bugs, "stink" bugs, and others being easily found in numbers beneath loose bark or hidden between the root leaves of mullein and other plants.

Nearly three hundred species of *Coleoptera*, or

beetles, occupy similar positions. Almost any rotten log or stump when broken open discloses a half dozen or more "horn" or "bess beetles," *Passalus cornutus* L., great, shining, clumsy, black fellows with a curved horn on the head. They are often utilized as horses by country children, the horn furnishing an inviting projection to which may be fastened, by a thread or cord, chips and pieces of bark to be dragged about by the strong and never lagging beast of burden. When tired of "playing horse" they can make of the insect an instrument of music; for, when held by the body, it emits a creaking, hissing noise, produced by rubbing the abdomen up and down against the inside of the hard, horny wing covers. This beetle passes its entire life in cavities in the rotten wood on which it feeds, and when it wishes a larger or more commodious home it has only to eat the more.



THIRTEEN-SPOTTED LADY BEETLE.

The handsome and beneficial lady beetles winter beneath fallen leaves or between and beneath the root leaves of the mullein and the thistle. Our most common species, the thirteen-spotted lady beetle, *Megilla maculata* De G., is gregarious, collecting together by thousands on the approach of cold weather, and lying huddled up like sheep until a breath of spring gives them the signal to disperse. Snout beetles galore can be found beneath piles of weeds near streams and the borders of ponds or beneath chunks and logs in sandy

places. All are injurious, and the farmer by burning their hibernating places in winter can cause their destruction in numbers. Rove beetles, ground beetles, and many others live deep down in the vegetable mould beneath old logs, where they are, no doubt, as secure from the ice king as if they followed the swallow to the tropics.

Of the *Diptera*, or flies, but few forms winter in the perfect state, yet the myriads of house flies and their kin, which next summer will distract the busy housewife, are represented in winter by a few isolated individuals which creep forth occasionally from crevice or cranny and greet us with a friendly buzz.

In mid-winter one may also see in the air swarms of small, gnat-like insects. They belong to this order and live beneath the bark of freshly fallen beech and other logs. On warm, sunny days they go forth in numbers for a sort of rhythmical courtship; their movements while in the air being peculiar in that they usually rise and fall in the same vertical line — performing a curious aërial dance which is long continued.

Among the dozen or more butterflies and moths which winter in the perfect state, the most common and the most handsome is the "Camberwell beauty" or "mourning cloak," *Vanessa antiopa* L., a large butterfly whose wings are a rich purplish brown above, duller beneath, and broadly margined with a yellowish band. It is often found in winter beneath chunks which are raised a short distance above the ground, or in the crevices of old snags and fence rails. It is then apparently lifeless, with the antennæ resting close along the back, above which the wings are folded. But one or

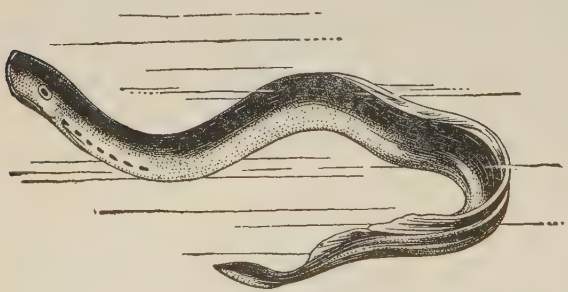
two warm days are necessary to restore it to activity, and I have seen it on the wing as early as the 2d of March, hovering over the open flowers of the little snow trillium.

All the species of ants survive the winter as mature forms, either in their nests in the ground or huddled groups in half rotten logs and stumps; while here and there beneath logs a solitary queen bumble-bee, bald hornet, or yellow jacket is found — the sole representatives of their races.

Thus insects survive the winter in many ways and in many places, some as eggs, others as larvæ, still others as pupæ, and a large number as adults — all being able to withstand severe cold and yet retain vitality sufficient to recover, live, grow, and replenish the earth with their progeny when the halcyon days of spring appear once more.

In the scale of animal life the vertebrates or backboned animals succeed the insects. Beginning with the fishes, we find that in late autumn they mostly seek some deep pool in pond or stream at the bottom of which the water does not freeze. Here the herbivorous forms eke out a precarious existence by feeding upon the innumerable diatoms and other small plants which are always to be found in water, while the carnivorous prey upon the herbivorous, and so maintain the struggle for existence. The moving to these deeper channels and pools in autumn and the scattering in the spring of the assembly which has gathered there constitute the so-called "migration of fishes," which is far from being so extensive and methodical as that practiced by the migratory birds.

Many of the smaller species of fishes, upon leaving these winter resorts, ascend small, clear brooks in large numbers for the purpose of depositing their eggs; as, when hatched in such a place, the young will be comparatively free from the attacks of the larger carnivorous forms. Among the lowest vertebrate often found in numbers in early spring in these meadow rills and brooks is the lamprey, *Ammocœtes branchialis* (L.), or "lamper eel," as it is sometimes called. It has a slender eel-like body, of a uniform leaden or blackish color, and with seven purse-shaped gill openings on each side. The mouth is fitted for sucking rather than biting, and with it they attach themselves to the bodies of fishes and feed on their flesh, which they scrape off with their rasp-like teeth. Later in the season they disappear from these smaller streams, probably returning in midsummer to deeper water. Thoreau, who studied their habits closely, says of them: "They are rarely seen on their way down stream, and it is thought by fishermen that they never return, but waste away and die, clinging to rocks and stumps of trees for an indefinite period; a tragic feature to the scenery of the river bottoms worthy to be remembered with Shakespeare's description of the sea floor."

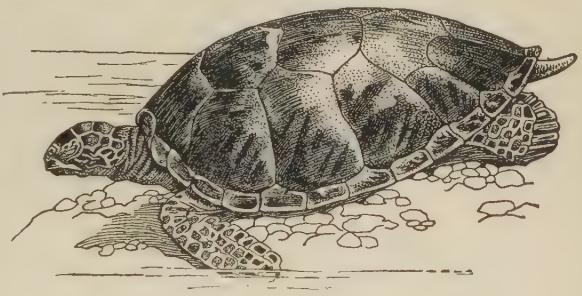


A Lamprey.

A few of the fishes, as the mud minnow and smaller

catfishes, together with most frogs, turtles, and salamanders, on the approach of winter, burrow into the mud at the bottom of the streams and ponds, or beneath logs near their margins. There they live without moving about and with all the vital processes in a partially dormant condition, thus needing little if any food.

The box tortoise or "dry land terrapin," the common toad, and some salamanders burrow into the dry earth, usually going deep enough to escape frost; while snakes seek some crevice in the rocks or hole in the ground where they coil themselves together, oftentimes in vast numbers, and prepare for their winter's sleep. In an open winter this hibernation is often interrupted, the animal emerging from its retreat and seeking its usual summer haunts as though spring had come again. Thus I have, on one occasion, seen a soft-shelled turtle moving gracefully over the bottom of a stream on a day in late December, and have in mid-January captured snakes and salamanders from beneath a pile of drift-wood, where they had taken temporary refuge.



TURTLE.

With frogs, especially, this hibernation is not a perfect one, and there is a doubt if in a mild winter some species hibernate at all. For example, the little cricket

frog or "peeper" has been seen many times in mid-winter alongside the banks of flowing streams, and during the open winter of 1888–89 numerous specimens of leopard and green frogs were seen on different occasions in December and January, while on February 18th they, together with the "peepers," were in full chorus.

Of our mammals, a few of the rodents or gnawers, as the ground-hogs, gophers and chipmunks, hibernate in burrows deep enough to escape the cold, and either feed on a stored supply of food, or, like the snakes and crayfish, do not feed at all.

CHIPMUNK.

Others, as the rabbits, field-mice, and squirrels, are more or less active and forage freely on whatever they can find, eating many things which in summer they would spurn with scorn. To this class belongs that intelligent but injurious animal the musquash or musk-rat. Those which inhabit the rivers and larger streams live in burrows dug deep beneath the banks, but those inhabiting sluggish streams and ponds usually construct a conical winter house about three feet in diameter and from two to three feet in height. These houses are made of coarse grasses, rushes, branches of shrubs, and small pieces of driftwood, closely cemented together with stiff, clayey mud. The top of the house usually

projects two feet or more above the water, and when sun-dried is so strong as to easily sustain the weight of a man. The walls are generally about six inches in thickness and are very difficult to pull to pieces. Within is a single circular chamber with a shelf or floor of mud, sticks, leaves and grass, ingeniously supported on coarse sticks stuck endwise into the mud after the manner of piles. In the centre of this floor is an opening, from which six or eight diverging paths lead to the open water without, so that the little artisan has many avenues of escape in case of danger. These houses are often repaired and used for several winters in succession, but are vacated on the approach of spring. During the summer the muskrat is, in the main, a herbivorous animal, but in winter necessity develops its carnivorous propensities and it feeds then mainly upon the mussels and crayfish which it can dig from the bottom of the pond or stream in which its house is built.

The bats pass the winter in caves, the attics of houses, and barns, or in hollow trees, hanging downward by their hind claws. Motionless for months they thus remain, and those in the more exposed situations are, doubtless, frozen solid. Yet, in time, their blood flows freely once again and they become as expert on the wing as though the year were one continual jubilee of insect chasing, and frost and snow were to them unknown.

All the carnivora, or flesh-eaters, as the mink, skunk, opossum, fox, and wolf, are in winter active and voracious, needing much food to supply the necessary animal heat of the body. Hence they are then much more

bold than in summer, and the hen yard or sheep pen of the farmer is too frequently called upon to supply this extra demand.

But of all our animals it seems to me the birds have solved the winter problem best. Possessing an enduring power of flight and a knowledge of a southern sunny sky, beneath which food is plentiful, they alone of all the living forms about us have little fear of the coming of the frost. True, fifty or more species remain in each of the Northern States during the cold season, but they are hardy birds which feed mainly upon seeds,

A Wolf.

as the snow-bird and song sparrow; on flesh, as the hawks and crows; or on burrowing insects, as the nuthatches and woodpeckers.

Such are some of the solutions to the problem of life in winter which the plants and animals about us have worked out; such some of the forms which they undergo; the places which they inhabit.

To the thinking mind a knowledge of these solutions but begets other and greater problems, such as how can a living thing be frozen solid for weeks and yet retain vitality enough to fully recover? How can a warm-blooded animal sleep for months without partaking of

food or drink? And greater than either, what is that which we call life?

I hold in my hand two objects, similar in size, color, organs, everything — twins from the same mother in all outward respects. One pulsates and throbs with that which we call "life." It possesses heat, bodily motion, animal power. The other is cold, motionless, pulseless, throbless — a thing of clay. What is that "life" which the one possesses and the other lacks? Ah, there's the rub! With the wisest of men we can only answer, "*Quien sabe?*" (Who knows?)

Winter House of Muskrat.

BIRDS' NESTS

(From Wake Robin.)[1]

By JOHN BURROUGHS.

HOW alert and vigilant the birds are, even when absorbed in building their nests! In an open space in the woods, I see a pair of cedar-birds collecting moss from the top of a dead tree. Following the direction in which they fly, I soon discover the nest placed in the fork of a small soft-maple, which stands amid a thick growth of wild-cherry trees and young beeches. Carefully concealing myself beneath it, without any fear that the workmen will hit me with a chip or let fall a tool, I await the return of the busy pair. Presently I hear the well-known note, and the female sweeps down and settles unsuspectingly into the half-finished structure. Hardly have her wings rested, before her eye has penetrated my screen, and with a hurried movement of alarm, she darts away. In a moment, the

[1] Copyright by Houghton, Mifflin & Co.

male, with a tuft of wool in his beak (for there is a sheep pasture near), joins her, and the two reconnoitre the premises from the surrounding bushes. With their beaks still loaded, they move around with a frightened look, and refuse to approach the nest till I have moved off and lain down behind a log. Then one of them ventures to alight upon the nest, but, still suspecting all is not right, quickly darts away again. Then they both together come, and after much peeping and spying about, and apparently much anxious consultation, cautiously proceed to work. In less than half an hour, it would seem that wool enough has been brought to supply the whole family, real and prospective, with socks, if needles and fingers could be found fine enough to knit it up. In less than a week, the female has begun to deposit her eggs, — four of them in as many days, — white tinged with purple, with black spots on the larger end. After two weeks of incubation, the young are out.

Excepting the American goldfinch, this bird builds later in the spring than any other, its nest, in our northern climate, seldom being undertaken till July. As with the goldfinch, the reason is, probably, that suitable food for the young cannot be had at an earlier period.

Like most of our common species, as the robin, sparrow, bluebird, pewee, wren, etc., this bird sometimes seeks wild, remote localities in which to rear its young; at others, takes up its abode near that of man. I knew a pair of cedar-birds, one season, to build in an apple-tree, the branches of which rubbed against the house. For a day or two before the first straw was

laid, I noticed the pair carefully exploring every branch of the tree the female taking the lead, the male following her with an anxious note and look. It was evident that the wife was to have her choice this time; and, like one who thoroughly knew her mind, she was proceeding to take it. Finally the site was chosen upon a high branch extending over one low wing of the house. Mutual congratulations and caresses followed, when both birds flew away in quest of building material. That most freely used is a sort of cotton-bearing plant, which grows in old, worn-out fields. The nest is large for the size of the bird, and very soft. It is in every respect a first-class domicile.

On another occasion, while walking, or rather sauntering, in the woods (for I have discovered that one cannot run and read the book of nature), my attention was arrested by a dull hammering, evidently but a few rods off. I said to myself, "Some one is building a house." From what I had previously seen, I suspected the builder to be a red-headed woodpecker, in the top of a dead oak stub near by. Moving cautiously in that direction, I perceived a round hole, about the size of that made by an inch-and-a-half auger, near the top of the decayed trunk, and the white chips of the workman strewing the ground beneath. When but a few paces from the tree, my foot pressed upon a dry twig, which gave forth a very slight snap. Instantly the hammering ceased, and a scarlet head appeared at the door. Though I remained perfectly motionless, forbearing even to wink till my eye smarted, the bird refused to go on with his work, but flew quietly off to a neighboring tree. What surprised me was, that amid

his busy occupation down in the heart of the old tree he should have been so alert and watchful as to catch the slightest sound from without.

The woodpeckers all build in about the same manner, excavating the trunk or branch of a decayed tree, and depositing the eggs on the fine fragments of wood at the bottom of the cavity. Though the nest is not especially an artistic work, — requiring strength rather than skill, — yet the eggs and the young of few other birds are so completely housed from the elements, or protected from their natural enemies — the jays, crows, hawks, and owls. A tree with a natural cavity is never selected, but one which has been dead just long enough to have become soft and brittle throughout. The bird goes in horizontally for a few inches, making a hole perfectly round and smooth and adapted to his size; then turns downward, gradually enlarging the hole, as he proceeds, to the depth of ten, fifteen, twenty inches, according to the softness of the tree and the urgency of the mother bird to deposit her eggs. While excavating, male and female work alternately. After one has been engaged fifteen or twenty minutes, drilling, and carrying out chips, it ascends to an upper limb, utters a loud call or two, when its mate soon appears, and, alighting near it on the branch, the pair chatter and caress a moment; then the fresh one enters the cavity and the other flies away.

A few days since, I climbed up to the nest of the downy woodpecker, in the decayed top of a sugar-maple. For better protection against driving rains, the hole which was rather more than an inch in diameter, was made immediately beneath a branch

which stretched out almost horizontally from the main stem. It appeared merely a deeper shadow upon the dark and mottled surface of the bark with which the branches were covered, and could not be detected by the eye until one was within a few feet of it. The young chirped vociferously as I approached the nest, thinking it was the old one with food; but the clamor suddenly ceased as I put my hand on that part of the trunk in which they were concealed, the unusual jarring and rustling alarming them into silence. The cavity, which was about fifteen inches deep, was gourd-shaped, and was wrought out with great skill and regularity. The walls were quite smooth and clean and new.

Woodpecker's Nest.
(Dotted lines indicate inside of nest and eggs).

I shall never forget the circumstance of observing a pair of yellow-bellied woodpeckers, — the most rare and secluded, and, next to the red-headed, the most beautiful species found in our woods, — breeding in an old, truncated beech in the Beaverkill Mountains, an off-shoot of the Catskills. We had been travelling, three of us, all day in search of a trout lake, which lay far in among the mountains, had twice lost our course in the

trackless forest, and, weary and hungry, had sat down to rest upon a decayed log. The chattering of the young, and the passing to and fro of the parent birds, soon arrested my attention. The entrance to the nest was on the east side of the tree, about twenty-five feet from the ground. At intervals of scarcely a minute, the old birds, one after another, would light upon the edge of the hole with a grub or worm in their beaks; then each in turn would make a bow or two, cast an eye quickly around, and by a single movement place itself in the neck of the passage. Here it would pause a moment, as if to determine in which expectant mouth to place the morsel, and then disappear within. In about half a minute, during which time the chattering of the young gradually subsided, the bird would again emerge, but this time bearing in its beak the ordure of one of the helpless family. Flying away very slowly with head lowered and extended, as if anxious to hold the offensive object as far from its plumage as possible, the bird dropped the unsavory morsel in the course of a few yards, and, alighting on a tree, wiped its bill on the bark and moss. This seemed to be the order all day,— carrying in and carrying out. I watched the birds for an hour, while my companions were taking their turn in exploring the lay of the land around us, and noted no variation in the programme. It would be curious to know if the young are fed and waited upon in regular order, and how, amid the darkness and the crowded state of the apartment, the matter is so neatly managed. But ornithologists are all silent upon the subject.

This practice of the birds is not so uncommon as it

might at first seem. It is, indeed, almost an invariable rule among all land birds. With woodpeckers and kindred species, and with birds that burrow in the ground, as bank swallows, kingfishers, etc., it is a necessity. The accumulation of the excrement in the nest would prove most fatal to the young.

But even among birds that neither bore nor mine, but which build a shallow nest on the branch of a tree or upon the ground, as the robin, the finches, the buntings, etc., the ordure of the young is removed to a distance by the parent bird. When the robin is seen going away from its brood with a slow, heavy flight, entirely different from its manner a moment before on approaching the nest with a cherry or worm, it is certain to be engaged in this office. One may observe the social sparrow, when feeding its young, pause a moment after the worm has been given, and hop around on the brink of the nest, observing the movements within.

The instinct of cleanliness no doubt prompts the action in all cases, though the disposition to secrecy or concealment may not be unmixed with it.

The swallows form an exception to the rule, the excrement being voided by the young over the brink of the nest. They form an exception, also, to the rule of secrecy, aiming not so much to conceal the nest as to render it inaccessible.

Other exceptions are the pigeons, hawks, and waterfowls.

But to return. Having a good chance to note the color and markings of the woodpeckers as they passed in and out at the opening of the nest, I saw that Audubon had made a mistake in figuring or describing the

female of this species with the red spot upon the head. I have seen a number of pairs of them, and in no instance have I seen the mother bird marked with red.

The male was in full plumage, and I reluctantly shot him for a specimen. Passing by the place again next day, I paused a moment to note how matters stood. I confess it was not without some compunctions that I heard the cries of the young birds, and saw the widowed mother, her cares now doubled, hastening to and fro in the solitary woods. She would occasionally pause expectantly on the trunk of a tree, and utter a loud call.

It usually happens when the male of any species is killed during the breeding season, that the female soon procures another mate. There are, most likely, always a few unmated birds of both sexes, within a given range, and through these the broken links may be restored. Audubon or Wilson, I forgot which, tells a pair of fish-hawks, or ospreys, that built their nest in an ancient oak. The male was so zealous in the defence of the young that it actually attacked with beak and claw a person who attempted to climb into his nest, putting his face and eyes in great jeopardy. Arming himself with a heavy club, the climber felled the gallant bird to the ground and killed him. In the course of a few days, the female had procured another mate. But naturally enough the step-father showed none of the spirit and pluck in defence of the brood that had been displayed by the original parent. When danger was nigh, he was seen afar off, sailing around in placid unconcern.

It is generally known that when either the wild turkey or domestic turkey begins to lay, and afterwards

to sit and rear the brood, she secludes herself from the male, who then, very sensibly, herds with others of his sex, and betakes himself to haunts of his own till male and female, old and young, meet again on common ground, late in the fall. But rob the sitting bird of her eggs, or destroy her tender young, and she immediately sets out in quest of a male, who is no laggard when he hears her call. The same is true of ducks and other aquatic fowls. The propagating instinct is strong, and surmounts all ordinary difficulties. No doubt the widowhood I had caused in the case of the woodpeckers was of short duration, and chance brought, or the widow drummed up, some forlorn male, who was not dismayed by the prospect of having a large family of half grown birds on his hands at the outset.

I have seen a fine cock robin paying assiduous addresses to a female bird as late as the middle of July; and I have no doubt that his intentions were honorable. I watched the pair for half an hour. The hen, I took it, was in the market for the second time that season; but the cock, from his bright, unfaded plumage, looked like a new arrival. The hen resented every advance of the male. In vain he strutted around her and displayed his fine feathers; every now and then she would make at him in a most spiteful manner. He followed her to the ground, poured into her ear a fine, half-suppressed warble, offered her a worm, flew back to the tree again with a great spread of plumage, hopped around her on the branches, chirruped, chattered, flew gallantly at an intruder, and was back in an instant at her side. No use, — she cut him short at every turn.

THE YELLOW-BELLIED WOODPECKER.

The *dénouement* I cannot relate, as the artful bird, followed by her ardent suitor, soon flew away beyond my sight. It may not be rash to conclude, however that she held out no longer than was prudent.

On the whole, there seems to be a system of Women's Rights prevailing among the birds, which, contemplated from the standpoint of the male, is quite admirable. In almost all cases of joint interest, the female bird is the most active. She determines the site of the nest, and is usually the most absorbed in its construction. Generally, she is more vigilant in caring for the young, and manifests the most concern when danger threatens. Hour after hour I have seen the mother of a brood of blue grossbeaks pass from the nearest meadow to the tree that held her nest, with a cricket or grasshopper in her bill, while her better-dressed half was singing serenely on a distant tree or pursuing his pleasure amid the branches.

Yet among the majority of our song birds, the male is most conspicuous both by his color and manners and by his song, and is to that extent a shield to the female. It is thought that the female is humbler clad for her better concealment during incubation. But this is not satisfactory, as in some cases she is relieved from time to time by the male. In the case of the domestic dove, for instance, promptly at mid-day the cock is found upon the nest. I should say that the dull or neutral tints of the female were a provision of nature for her greater safety at all times, as her life is far more precious to the species than that of the male. The indispensable office of the male reduces itself to little more than a moment of time, while that of his mate extends over days and weeks, if not months.

In migrating northward, the males precede the females by eight or ten days; returning in the fall, the females and young precede the males by about the same time.

After the woodpeckers have abandoned their nests, or rather chambers, which they do after the first season, their cousins, the nut-hatches, chickadees, and brown creepers, fall heir to them. These birds, especially the creepers and nut-hatches, have many of the habits of the *picidæ*, but lack their powers of bill, and so are unable to excavate a nest for themselves. Their habitation, therefore, is always second-hand. But each species carries in some soft material of various kinds, or, in other words, furnishes the tenement to its liking. The chickadee arranges in the bottom of the cavity a little mat of a light, felt-like substance, which looks as if it came from the hatter's, but which is probably the work of numerous worms or caterpillars. On this soft lining the female deposits six white eggs.

Nest of the Chickadee.

I recently discovered one of these nests in a most interesting situation. The tree containing it, a variety of the wild cherry, stood upon the brink of the bald summit of a high mountain. Gray, time-worn rocks lay piled loosely about, or overtoppled the just visible by-ways of the red fox. The trees had a half-scared look, and that indescribable wildness which lurks about the tops of all remote mountains possessed the place. Standing there, I looked down upon the back of the red-tailed hawk as he flew out over the earth beneath me. Following him, my eye also took in farms, and settlements, and villages, and other mountain ranges that grew blue in the distance.

The parent birds attracted my attention by appearing with food in their beaks, and by seeming much put out. Yet so wary were they of revealing the locality of their brood, or even of the precise tree that held them, that I lurked around over an hour without gaining a point on them. Finally a bright and curious boy who accompanied me secreted himself under a low, projecting rock close to the tree in which we supposed the nest to be, while I moved off around the mountain-side. It was not long before the youth had their secret. The tree, which was low and wide branching, and overrun with lichens, appeared at a cursory glance to contain not one dry or decayed limb. Yet there was one a few feet long, in which, when my eyes were piloted thither, I detected a small round orifice.

As my weight began to shake the branches, the consternation of both old and young was great. The stump of a limb that held the nest was about three inches thick, and at the bottom of the tunnel was excavated

quite to the bark. With my thumb I broke in the thin wall, and the young, which were full-fledged, looked out upon the world for the first time. Presently one of them, with a significant chirp, as much as to say, "It is time we were out of this," began to climb up toward the proper entrance. Placing himself in the hole, he looked around without manifesting any surprise at the grand scene that lay spread out before him. He was taking his bearings and determining how far he could trust the power of his untried wings to take him out of harm's way. After a moment's pause, with a loud chirrup, he launched out, and made tolerable headway. The others rapidly followed. Each one, as it started upward, from a sudden impulse, contemptuously saluted the abandoned nest with its excrement.

Though generally regular in their habits and instincts, yet the birds sometimes seem as whimsical and capricious as superior beings. One is not safe, for instance, in making any absolute assertion as to their place or mode of building. Ground builders often get up into a bush, and tree builders sometimes get upon the ground or into a tussock of grass. The song-sparrow, which is a ground builder, has been known to

Barn Swallow and Nest.

build in the knot-hole of a fence rail, and a chimney swallow once got tired of soot and smoke, and fastened its nest on a rafter in a hay barn. A friend tells me of a pair of barn swallows which, taking a fanciful turn, saddled their nest in the loop of a rope that was pendent from a peg in the peak, and liked it so well that they repeated the experiment next year. I have known the social sparrow, or "hair bird," to build under a shed, in a tuft of hay that hung down, through the loose flooring, from the mow above. It usually contents itself with a half a dozen stalks of dry grass and a few long hairs from a cow's tail, loosely arranged on the branch of an apple-tree. The rough-winged swallow builds in the wall and in old stone heaps, and I have seen the robin build in similar localities. Others have found its nest in old, abandoned wells. The house wren will build in anything that has an accessible cavity, from an old boot to a bombshell. A pair of them once persisted in building their nest in the top of a certain pump-tree, getting in through the opening above the handle. The pump being in daily use, the nest was destroyed more than a score of times. This jealous little wretch has the wise forethought, when the box in which he builds contains two compartments, to fill up one of them, so as to avoid the risk of troublesome neighbors.

The less skilful builders sometimes depart from their usual habit, and take up with the abandoned nest of some other species. The blue-jay now and then lays in an old crow's-nest or cuckoo's-nest. The crow-blackbird, seized with a fit of indolence, drops its eggs in the cavity of a decayed branch. I heard of a cuckoo

that dispossessed a robin of its nest; of another that set a blue-jay adrift. Large, loose structures, like the nests of the osprey and certain of the herons, have been found with half a dozen nests of the blackbird set in the outer edges, like so many parasites, or, as Audubon says, like the retainers about the rude court of a feudal baron.

Baltimore Oriole and Nest.

The same birds breeding in a southern climate construct far less elaborate nests than when breeding in a northern climate. Certain species of water-fowl that abandon their eggs to the sand and the sun in the warmer zones, build a nest and sit in the usual way in Labrador. In Georgia, the Baltimore oriole places its nest upon the north side of the tree; in the Middle and Eastern States, it fixes it upon the south or east side, and makes it much thicker and warmer. I have seen one from the South that had some kind of coarse reed or sedge woven into it, giving it an open-work appearance, like a basket.

Very few species use the same material uniformly. I have seen the nest of the robin quite destitute of mud. In one instance, it was composed mainly of long, black horse-hairs, arranged in a circular manner, with a lining of fine yellow grass; the whole presenting quite a novel appearance. In another case, the nest was chiefly constructed of a species of rock moss.

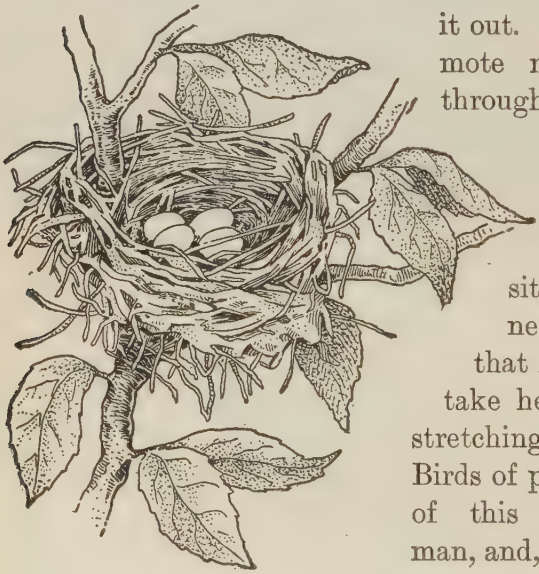
The nest for the second brood during the same season is often a mere make-shift. The haste of the female to deposit her eggs as the season advances seems very great, and the structure is apt to be prematurely finished. I was recently reminded of this fact by happening, about the last of July, to meet with several nests of the wood or bush sparrow in a remote blackberry field. The nests with eggs were far less elaborate and compact than the earlier nests, from which the young had flown.

Day after day, as I go to a certain piece of woods, I observe a male indigo-bird sitting on precisely the same part of a high branch, and singing in his most vivacious style. As I approach, he ceases to sing, and, flirting his tail right and left with marked emphasis, chirps sharply. In a low bush near by, I come upon the object of his solicitude, a thick, compact nest, composed largely of dry leaves and fine grass, in which a plain brown bird is sitting upon four pale blue eggs.

The wonder is, that a bird will leave the apparent security of the tree-tops, to place its nest in the way of the many dangers that walk and crawl upon the ground. There, far out of reach, sings the bird; here, not three feet from the ground, are its eggs or helpless young. The truth is, birds are the greatest enemies of birds,

and it is with reference to this fact that many of the smaller species build.

Perhaps the greatest proportion of birds breed along highways. I have known the ruffed grouse to come out of a dense wood and make its nest at the root of a tree within ten paces of the road, where, no doubt, hawks and crows, as well as skunks and foxes, would be less liable to find it out. Traversing remote mountain-roads through dense woods, I have repeatedly seen the veery, or Wilson's thrush, sitting upon her nest, so near me that I could almost take her from it by stretching out my hand. Birds of prey show none of this confidence in man, and, when locating their nests, avoid rather than seek his haunts.



Indigo Bird's Nest.

In a certain locality in the interior of New York, I know, every season, where I am sure to find a nest or two of the slate-colored snow-bird. It is under the brink of a low, mossy bank, so near the highway that it could be reached from a passing vehicle with a whip. Every horse or wagon or foot passenger disturbs the sitting bird. She awaits the near approach of a sound

of feet or wheels, and then darts quickly across the road, barely clearing the ground, and disappears amid the bushes on the opposite side.

In the trees that line one of the main streets and fashionable drives leading out of Washington city, and less than half a mile from the boundary, I have counted the nests of five different species at one time, and that without any very close scrutiny of the foliage, while in many acres of woodland, half a mile off, I searched in vain for a single nest. Among the five that interested me most was that of a blue grossbeak. Here this bird, which, according to Audubon's observations, in Louisiana is shy and recluse, affecting remote marshes and the borders of large ponds of stagnant water, had placed its nest in the lowest twig of the lowest branch of a large sycamore, immediately over a great thoroughfare, and so near the ground that a person standing in a cart or sitting on a horse could have reached it with his hand. The nest was composed mainly of fragments of newspaper and stalks of grass, and, though so low, was remarkably well concealed by one of the peculiar clusters of twigs and leaves which characterize this tree. The nest contained young when I discovered it, and though the parent birds were much annoyed by my loitering about beneath the tree, they paid little attention to the stream of vehicles that was constantly passing. It is a wonder to me when the birds could have built it, for they are much shyer when building than at other times. No doubt they worked mostly in the morning, having the early hours all to themselves.

Another pair of blue grossbeaks built in a graveyard

within the city limits. The nest was placed in a low bush, and the male continued to sing at intervals till the young were ready to fly. The song of this bird is a rapid, intricate warble, like that of the indigo-bird, though stronger and louder. Indeed, these two birds so much resemble each other in color, form, manner, voice, and general habits that, were it not for the difference in size, — the grossbeak being nearly as large again as the indigo-bird, — it would be a hard matter to tell them apart. The females of both species are clad in the same reddish-brown suits. So are the young the first season.

Of course in the deep, primitive woods also are nests, but how rarely we find them! The simple art of the bird consists in choosing common, neutral-tinted material, as moss, dry leaves, twigs, and various odds and ends, and placing the structure on a convenient branch, where it blends in color with its surroundings; but how consummate is this art, and how skilfully is the nest concealed! We occasionally light upon it, but who, unaided by the movements of the bird, could find it out? During the present season, I went to the woods nearly every day for a fortnight, without making any discoveries of this kind, till one day, paying them a farewell visit, I chanced to come upon several nests. A black and white creeping warbler suddenly became much alarmed as I approached a crumbling old stump in a dense part of the forest. He alighted upon it, chirped sharply, ran up and down its sides, and finally left it with much reluctance. The nest, which contained three young birds nearly fledged, was placed upon the ground, at the foot of the stump, and in such

a position that the color of the young harmonized perfectly with the bits of bark, sticks, etc., lying about. My eye rested upon them for the second time before I made them out. They hugged the nest very closely, but as I put down my hand they scampered off with loud cries for help, which caused the parent birds to place themselves almost within my reach. The nest was merely a little dry grass arranged in a thick bed of dry leaves.

This was amid a thick undergrowth. Moving on into a passage of large, stately hemlocks, with only here and there a small beech or maple rising up into the perennial twilight, I paused to make out a note which was entirely new to me. It is still in my ear. Though unmistakably a bird note, it yet suggested the bleating of a tiny lambkin. Presently the birds appeared, — a pair of the solitary vireo. They came flitting from point to point, alighting only for a moment at a time, the male silent, but the female uttering this strange, tender note. It was a rendering into some new sylvan dialect of the human sentiment of maidenly love. It was really pathetic in its sweetness and childlike confidence and joy. I soon discovered that the pair were building a nest upon a low branch a few yards from me. The male flew cautiously to the spot, and adjusted something, and the twain moved on, the female calling to her mate at intervals, *love-e*, *love-e*, with a cadence and tenderness in the tone that rang in the ear long afterward. The nest was suspended to the fork of a small branch, as is usual with the vireos, plentifully lined with lichens, and bound and rebound with masses of coarse spider-webs. There

was no attempt at concealment except in the neutral tints, which made it look like a natural growth of the dim, gray woods.

Continuing my random walk, I next paused in a low part of the woods, where the larger trees began to give place to a thick second growth that covered an old Bark-peeling. I was standing by a large maple, when a small bird darted quickly away from it, as if it might have come out of a hole near its base. As the bird paused a few yards from me, and began to chirp uneasily, my curiosity was at once excited. When I saw it was the female mourning ground warbler, and remembered that the nest of this bird had not yet been seen by any naturalist, — that not even Dr. Brewer had ever seen the eggs, — I felt that here was something worth looking for. So I carefully began the search, exploring inch by inch the ground, the base and roots of the tree, and the various shrubby growths about it, till, finding nothing, and fearing I might really put my foot in it, I bethought me to withdraw to a distance and after some delay return again, and, thus forewarned, note the exact point from which the bird flew. This I did, and, returning, had little difficulty in discovering the nest. It was placed but a few feet from the maple-tree, in a bunch of ferns, and about six inches from the ground. It was quite a massive nest, composed entirely of the stalks and leaves of dry grass, with an inner lining of fine, dark-brown roots. The eggs, three in number, were of light flesh color, uniformly specked with fine brown specks. The cavity of the nest was so deep that the back of sitting bird sank below the edge.

In the top of a tall tree, a short distance farther on, I saw the nest of the red-tailed hawk, — a large mass of twigs and dry sticks. The young had flown, but still lingered in the vicinity, and, as I approached, the mother bird flew about over me, squealing in a very angry, savage manner. Tufts of the hair and other indigestible material of the common meadow mouse lay around on the ground beneath the nest.

Nest of Red-eyed Vireo.

As I was about leaving the woods, my hat almost brushed the nest of the red-eyed vireo, which hung basket-like on the end of a low, drooping branch of the beech. I should never have seen it had the bird kept her place. It contained three eggs of the bird's own, and one of the cow-bunting. The strange egg was only just perceptibly larger than the others, yet three days after, when I looked into the nest again and found all but one egg hatched, the young inter-

loper was at least four times as large as either of the others, and with such a superabundance of bowels as to almost smother his bedfellows beneath them. That the intruder should fare the same as the rightful occupants, and thrive with them, was more than ordinary potluck; but that it alone should thrive, devouring, as it were, all the rest, is one of those freaks of Nature in which she would seem to discourage the homely virtues of prudence and honesty. Weeds and parasites have the odds greatly against them, yet they wage a very successful war nevertheless.

The woods hold not such another gem as the nest of the humming-bird. The finding of one is an event to date from. It is the next best thing to finding an eagle's nest. I have met with but two, both by chance. One was placed on the horizontal branch of a chestnut-tree, with a solitary green leaf, forming a complete canopy, about an inch and a half above it. The repeated spiteful dartings of the bird past my ears, as I stood under the tree, caused me to suspect that I was intruding upon some one's privacy; and following it with my eye, I soon saw the nest, which was in process of construction. Adopting my usual tactics of secreting myself near by, I had the satisfaction of seeing the tiny artist at work. It was the female, unassisted by her mate. At intervals of two or three minutes she would appear with a small tuft of some cottony substance in her beak, dart a few times through and around the tree, and alighting quickly in the nest arrange the material she had brought, using her breast as a model.

The other nest I discovered in a dense forest on the side of a mountain. The sitting bird was disturbed as

I passed beneath her. The whirring of her wings arrested my attention, when, after a short pause, I had the good luck to see, through an opening in the leaves, the bird return to her nest, which appeared like a mere wart or excrescence on a small branch. The humming-bird, unlike all others, does not alight upon the nest, but flies into it. She enters it as quick as a flash, but as light as any feather. Two eggs are the complement. They are perfectly white, and so frail that only a woman's fingers may touch them. Incubation lasts about ten days. In a week the young have flown.

The only nest like the humming-bird's, and comparable to it in neatness and symmetry, is that of the blue-gray gnat-catcher. This is often saddled upon the limb in the same manner, though it is generally more or less pendent; it is deep and soft, composed mostly of some vegetable down, covered all over with delicate tree-lichens, and, except that it is much larger, appears almost identical with the nest of the humming-bird.

But the nest of nests, the ideal nest, after we have left the deep woods, is unquestionably that of the Baltimore oriole. It is the only perfectly pensile nest we have. The nest of the orchard oriole is indeed mainly so, but this bird generally builds lower and shallower, more after the manner of the vireos.

The Baltimore oriole loves to attach its nest to the swaying branches of the tallest elms, making no attempt at concealment, but satisfied if the position be high and the branch pendent. This nest would seem to cost more time and skill than any other bird structure. A peculiar flax-like substance seems to be always

sought after, and always found. The nest when completed assumes the form of a large, suspended gourd. The walls are thin but firm, and proof against the most driving rain. The mouth is hemmed or overhanded with horse-hair, and the sides are usually sewed through and through with the same.

Not particular as to the matter of secrecy, the bird is not particular as to material, so that it be of the nature of strings or threads. A lady friend once told me that while working by an open window, one of these birds approached during her momentary absence, and, seizing a skein of some kind of thread or yarn, made off with it to its half-finished nest. But the perverse yarn caught fast in the branches, and, in the bird's efforts to extricate it, got hopelessly tangled. She tugged away at it all day, but was finally obliged to content herself with a few detached portions. The fluttering strings were an eye-sore to her ever after, and passing and repassing, she would give them a spiteful jerk, as much as to say, "There is that confounded yarn that gave me so much trouble."

From Pennsylvania, Vincent Barnard (to whom I am indebted for other curious facts) sent me this interesting story of an oriole. He says a friend of his, curious in such things, on observing the bird beginning to build, hung out near the prospective nest skeins of many-colored zephyr-yarn, which the eager artist readily appropriated. He managed it so that the bird used nearly equal quantities of various high, bright colors. The nest was made unusually deep and capacious, and it may be questioned if such a thing of beauty was ever before woven by the cunning of a bird.

Nuttall, by far the most genial of American ornithologists, relates the following: —

"A female (oriole), which I observed attentively, carried off to her nest a piece of lamp-wick ten or twelve feet long. This long string and many other shorter ones were left hanging out for about a week before both the ends were wattled into the sides of the nest. Some other little birds making use of similar materials, at times twitched these flowing ends, and generally brought out the busy Baltimore from her occupation in great anger.

"I may perhaps claim indulgence for adding a little more of the biography of this particular bird, as a representative, also, of the instincts of her race. She completed the nest in about a week's time, without any aid from her mate, who, indeed, appeared but seldom in her company, and was now become nearly silent. For fibrous materials she broke, hackled, and gathered the flax of the *asclepias* and *hibiscus* stalks, tearing off long strings and flying with them to the scene of her labors. She appeared very eager and hasty in her pursuits, and collected her materials without fear or restraint, while three men were working in the neighboring walks, and many persons visiting the garden. Her courage and perseverance were indeed truly admirable. If watched too narrowly, she saluted with her usual scolding, *tshrr*, *tshrr*, *tshrr*, seeing no reason, probably, why she should be interrupted in her indispensable occupation.

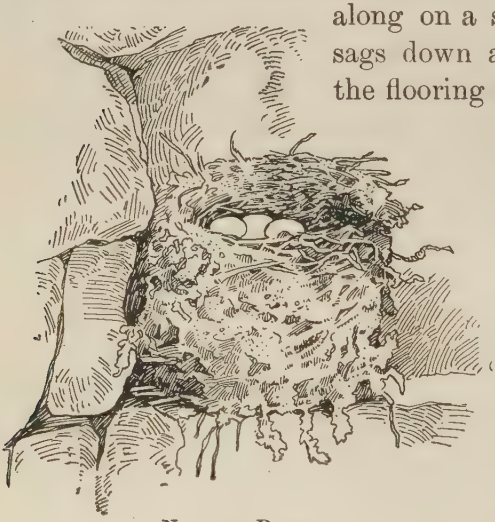
"Though the males were now comparatively silent on the arrival of their busy mates, I could not help observing this female and a second, continually vocif-

erating apparently in strife. At last she was observed to attack this second female very fiercely, who slyly intruded herself at times into the same tree where she was building. These contests were angry and often repeated. To account for this animosity, I now recollected that two fine males had been killed in our vicinity; and I therefore concluded the intruder to be left without a mate; yet she had gained the affections of the consort of the busy female, and thus the cause of their jealous quarrel became apparent. Having obtained the confidence of her faithless paramour, the second female began preparing to weave a nest in an adjoining elm, by tying together certain pendent twigs as a foundation. The male now associated chiefly with the intruder, whom he even assisted in her labor, yet did not wholly forget his first partner, who called on him one evening in a low, affectionate tone, which was answered in the same strain. While they were thus engaged in friendly whispers, suddenly appeared the rival, and a violent *rencontre* ensued, so that one of the females appeared to be greatly agitated, and fluttered with spreading wings as if considerably hurt. The male, though prudently neutral in the contest, showed his culpable partiality by flying off with his paramour, and for the rest of the evening left the tree to his pugnacious consort. Cares of another kind, more imperious and tender, at length reconciled, or at least terminated, these disputes with the jealous females; and by the aid of the neighboring bachelors, who are never wanting among these and other birds, peace was at length completely restored, by the restitution of the quiet and happy condition of monogamy."

Let me not forget to mention the nest under the mountain ledge, the nest of the common pewee, a modest mossy structure, with four pearl-white eggs, looking out upon some wild scene and overhung by beetling crags. After all has been said about the elaborate, high-hung structures, few nests, perhaps, awaken more pleasant emotions in the mind of the beholder than this of the pewee, — the gray, silent rocks, with caverns and dens where the fox and the wolf lurk, and just out of their reach, in a little niche, as if it grew there, the mossy tenement!

Nearly every high projecting rock in my range has one of these nests. Following a trout stream up a wild mountain gorge, not long since, I counted five in the distance of a mile, all within easy reach, but safe from the minks and the skunks, and well housed from the storms. In my native town I know a pine and oak clad hill, round-topped, with a bold, precipitous front extending half-way around it. Near the top, and along this front or side, there crops out a ledge of rocks unusually high and cavernous. One immense layer projects many feet, allowing a person or many persons, standing upright, to move freely beneath it. There is a delicious spring of water there, and plenty of wild, cool air. The floor is of loose stone, now trod by sheep and foxes, once by the Indian and the wolf. How I have delighted from boyhood to spend a summer-day in this retreat or take refuge there from a sudden shower! Always the freshness and coolness, and always the delicate mossy nest of the phœbe-bird! The bird keeps her place till you are within a few feet of her, when she flits to a near branch, and, with many oscillations

of her tail, observes you anxiously. Since the country has become settled, this pewee has fallen into the strange practice of occasionally placing its nest under a bridge, hay-shed, or other artificial structure, where it is subject to all kinds of interruptions and annoyances. When placed thus, the nest is larger and coarser. I know a hayloft beneath which a pair has regularly placed its nest for several successive seasons. Arranged along on a single pole, which sags down a few inches from the flooring it was intended to help support, are three of these structures, marking the number of years the birds have nested there. The foundation is of mud with a superstructure of moss, elaborately lined with hair and feathers. Nothing can be more perfect and exquisite than the interior of one of these nests, yet a new one is built every season. Three broods, however, are frequently reared in it.



Nest of Phœbe.

The pewees, as a class, are the best architects we have. The king-bird builds a nest altogether admirable, using various soft cotton and woollen substances, and sparing neither time nor material to make it substantial and warm. The green-crested pewee builds its

nest in many instances wholly of the blossoms of the white-oak. The wood pewee builds a neat, compact socket-shaped nest of moss and lichens on a horizontal branch. There is never a loose end or shred about it. The sitting bird is largely visible above the rim. She moves her head freely about, and seems entirely at her ease, — a circumstance which I have never observed in any other species. The nest of the great-crested fly-catcher is seldom free from snake skins, three or four being sometimes woven into it.

About the thinnest, shallowest nest, for its situation, that can be found is that of the turtle-dove. A few sticks and straws are carelessly thrown together, hardly sufficient to prevent the eggs from falling through or rolling off. The nest of the passenger pigeon is equally hasty and insufficient, and the squabs often fall to the ground and perish. The other extreme among our common birds is furnished by the ferruginous thrush, which collects together a mass of material that would fill a half-bushel measure; or by the fish-hawk, which adds to and repairs its nest year after year, till the whole would make a cart-load.

The rarest of all nests is that of the eagle, because the eagle is the rarest of all birds. Indeed, so seldom is the eagle seen, that its presence always seems accidental. It appears as if merely pausing on the way, while bound for some distant unknown region. One September, while a youth, I saw the ring-tailed eagle, an immense, dusky bird, the sight of which filled me with awe. It lingered about the hills for two days. Some young cattle, a two year-old colt, and half a dozen sheep were at pasture on a high ridge that led up to

the mountain, and in plain view of the house. On the second day, this dusky monarch was seen flying about above them. Presently he began to hover over them, after the manner of a hawk watching for mice. He then with extended legs let himself slowly down upon them, actually grappling the backs of the young cattle, and frightening the creatures so that they rushed about the field in great consternation; and finally, as he grew bolder and more frequent in his descents, the whole herd broke over the fence, and came tearing down to the house "like mad." It did not seem to be an assault with intent to kill, but was, perhaps, a stratagem resorted to in order to separate the herd and expose the lambs, which hugged the cattle very closely. When he occasionally alighted upon the oaks that stood near, the branch could be seen to sway and bend beneath him. Finally, as a rifleman started out in pursuit of him, he launched into the air, set his wings, and sailed away southward. A few years afterward, in January, another eagle passed through the same locality, alighting in a field near some dead animal, but tarried briefly.

EAGLE.

So much by way of identification. The bird is common to the northern parts of both hemispheres, and places its eyrie on high, precipitous rocks. A pair built on an inaccessible shelf of rock along the Hudson for eight successive years. A squad of Revolutionary soldiers also found a nest along this river, and had an adventure with the bird that came near costing one of their number his life. His comrades let him down by a rope to secure the eggs or young, when he was attacked by the female eagle with such fury that he was obliged to defend himself with his knife. In doing so, by a mis-stroke, he nearly severed the rope that held him, and was drawn up by a single strand from his perilous position. Audubon, from whom this anecdote is taken, figures and describes this bird as the golden eagle, though I have little doubt that Wilson was right, and that the golden eagle is a distinct species.

The sea-eagle also builds on high rocks, according to Audubon, though Wilson describes the nest of one which he saw near Great Egg Harbor, in the top of a large yellow pine. It was a vast pile of sticks, sods, sedge, grass, reeds, etc., five or six feet high by four broad, and with little or no concavity. It had been used for many years, and he was told that the eagles made it a sort of home or lodging-place in all seasons. This agrees with the description which Audubon gives of the nest of the bald eagle. There is evidently a little confusion on both sides.

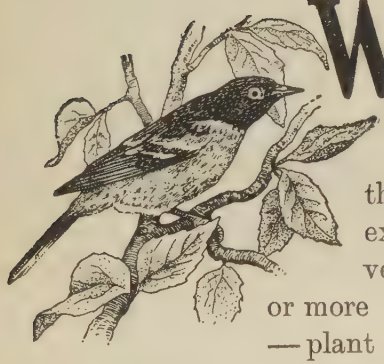
The eagle in all cases uses one nest, with more or less repair, for several years. Many of our common birds do the same. The birds may be divided, with respect to this and kindred points, into five general

classes. First, those that repair and appropriate the last year's nest, as the wren, swallow, blue-bird, great-crested flycatcher, owls, eagles, fish-hawk, and a few others. Secondly, those that build anew each season, though frequently rearing more than one brood in the same nest. Of these, the phœbe-bird is a well-known example. Thirdly, those that build a new nest for each brood, which includes by far the greatest number of species. Fourthly, a limited number that make no nest of their own, but appropriate the abandoned nests of other birds. Finally, those who use no nest at all, but deposit their eggs in the sand, which is the case with a large number of aquatic fowls. Thus the common gull breeds in vast numbers on the sand bars or sand islands off the south coast of Long Island. A little dent is made in the sand, the eggs are dropped, and the old birds go their way. In due time the eggs are hatched by the warmth of the sun, and the little creatures shift for themselves. In July countless numbers of them, of different ages and sizes, swarm upon these sandy wastes. As the waves roll out, they rush down the beach, picking up a kind of sea gluten, and then hasten back to avoid the next breaker.

BIRDS IN THEIR RELATION TO AGRICULTURE

(From the Proceedings of the Nebraska Ornithologists' Union, January, 1901.)[1]

By LAWRENCE BRUNER.



WHEN civilized man takes possession of new regions and begins cultivating the soil and establishes his sovereignty there, the equilibrium as it existed upon his arrival is very quickly disturbed. One or more of the many forms of life — plant and animal — that were previously held within certain limits gain ascendency. The introduction of new crops that furnish an abundance of the proper food for some insect, enables this form to increase out of all proportions and harm soon results. The killing off of certain other forms of life that naturally keep still others in check also assists in disturbing the equilibrium further. The cutting down and clearing away of forests removes the shelter and homes of others, as does also the turning under of

[1] By permission.

prairie grasses. Then, too, many of the natural residents of primeval forests and virgin prairies shun the sight of man, hence they gradually withdraw from the region, and their influence for good or evil goes with them. Since the majority of such forms are timid and inoffensive creatures, their withdrawal only adds that much more to the already overbalanced conditions. Year by year the gap which at first was scarcely noticeable becomes widened, so that frequent inroads are made and harm results. Instead of trying to ascertain the true cause for all this trouble perhaps exactly the wrong thing is done by the settlers. This of course only has the effect of further widening the gap between safety and danger. Since an insect or other animal becomes noticeably harmful only when present in alarming numbers, it stands to reason that anything which favors such an abnormal increase is a factor in disturbing nature and should be quickly rectified where possible. In order that these disturbances should be looked after the all-wise God of the universe created birds and gave them the power of flight that they might the more readily move about rapidly from place to place, where their services might be needed in balancing affairs. Hence birds have naturally and rightfully been called the "balancers" in nature. This being true, let us see just what their relations are to agriculture.

The farmer sows in order that he may reap an increased measure of what he has sown. In doing this he must first turn over the soil. This destroys many existing plants as well as animals that depend upon them for food. The plants thus turned down cannot

regain their position and must of necessity die. Not so with many of the animals, however, which soon work their way to the surface. Some of these attack the growing plants which have been made to occupy the place of those destroyed by the plough. Others take wing and seek suitable food in adjoining districts where they add to the numbers already drawing upon the vegetation up to the point of possible continued supply. Here, then, the scales begin to vibrate. In the field the new and tender crop entices the ever-shifting individuals of myriads of forms that have been crowded out elsewhere. The result here too is, or would be, very disastrous were it not for the timely visit of flocks of birds likewise in search of food.

It is during the period of first settlement of a country, when the fields are small, few and widely separated, that injury may and frequently does result from birds. It is then a problem that needs careful consideration, not only for the time being, but also for the future welfare of that country. If animal life is destroyed indiscriminately and without intelligent forethought, calamities unforeseen are sure to follow in the not distant future.

Birds can be useful to man in many ways. They can benefit him by carrying the seeds of various plants from place to place so as to assist him in establishing new groves in which to find shelter from the cold in winter and refuge from the heat of the noonday sun in summer. They plant various shrubs by the wayside that spring up and later are laden with luscious fruit. They also carry the spawn of fishes and small crustaceans among their feathers into new waters, and feed

upon the countless seeds of weeds that are scattered broadcast over the face of the earth. Some kinds live almost exclusively upon insects, while others hunt out the small rodents that would, if left to themselves, destroy great quantities of grain and other vegetation. Still other birds benefit mankind by acting as scavengers in the removal of putrid and other offensive matter which would endanger our health. In addition to all these varied direct benefits which are brought about by the presence of birds, man is further indebted to these creatures for the cheer which their gay music, bright plumage and pleasant manners bring to him. The birds form a carefully organized army of police which is engaged in keeping affairs balanced in nature.

But we can go even further summing up the benefits that men may derive from the birds. A great many kinds make excellent food, while others furnish sport and pleasure to a large number of men and boys who seem to require a certain kind of entertainment while accompanied with dog and gun. Dead birds when embalmed as mummies and attached to the head-gear worn by some girls and women are also claimed to cause much happiness.

Birds as Enemies.— It would be ridiculous for me to assert here that no injury ever results from the presence of birds on the farm or in the orchard. Quite a number of different species are continually stepping over to the wrong side of the "ledger" as it were, and committing depredations of various kinds which if considered alone would render the perpetrators liable to severe punishment — in some cases even unto death. Some of the crimes that can be charged to the feathered

tribe are cherry and berry-stealing, grape-puncturing, apple-pecking, corn-pulling, grain-eating, the unintentional carrying from place to place of some kinds of scale insects that happen to crawl on their legs and feet, the possible spreading of hog cholera by crows and buzzards, the robbing of the poultry yard, and lastly some birds are accused of making noises that awaken us from our slumbers in the morning.

Some of these crimes are genuine and are to be deplored, while others are more imaginary than real. A few of them could be prevented in part or altogether, while others might be diminished if we were inclined to take the trouble to do it.

After all that can be said pro and con concerning the usefulness of birds in general there remains no doubt, in the minds of thinking people at least, as to the value of these creatures. It is only the vicious, biased, and thoughtless persons who continue ruthlessly to destroy birds indiscriminately without first pausing to consider whether or not it is a proper thing to do, whether it is right or wrong.

Food habits. — So varied is this task of evening up in nature that if attended to properly the workers must be numerous in individuals and possess widely different habits. That such is the case can readily be seen by the following brief account of the various groups of our Nebraska birds, along with brief statements of their food habits.

The Grebes and Loons feed chiefly upon snails and other aquatic animals such as are found about their haunts. They also capture many grasshoppers and similar insects that happen in their way. They cannot,

therefore, be classed among the especially beneficial birds, neither can they be termed injurious on account of what they eat.

The Gulls, provided as they are with long wings and great powers for flight, are not confined to the sea-coast, hence they reach far inland in their migrations, feeding extensively upon insects like locusts, June-beetles, crickets, etc., large numbers of which they destroy annually. Several kinds of these birds are known to follow the plough and pick up the white grubs and other insects that are turned up and laid bare. In early days, when grasshoppers did much harm in this state, numerous flocks of these birds were seen to feed upon these insects.

The Cormorants and Pelicans are chiefly destroyers of fishes and frogs, hence can hardly be classed among the most beneficial forms; but whether or not they do any more than to maintain the necessary equilibrium in that particular part of the vast field of nature it is difficult to judge without time for investigation.

The various Ducks and Geese which are also nearly as aquatic in their habits as some of the foregoing, frequently leave their haunts and make excursions into the surrounding country where in summer they feed upon locusts, beetles, and other injurious insects. They also partake of considerable quantities of vegetable food, as grains, weed seeds, grasses, and other herbage. While not included among the insectivorous forms these birds do much towards diminishing the ever increasing horde of creeping and jumping things. Ducks and geese on the other hand are largely utilized by us as food: while their feathers make comfortable pillows and coverlets.

The Herons, Cranes, and Rails are frequenters of marshes and the margins of streams and bodies of water, where they assist in keeping the various forms among the animal life balanced. Fishes, frogs, snails, insects, and crustaceans are alike devoured by them.

The Snipe, Sandpipers, Plovers, Phalaropes, Curlews, etc., are great destroyers of insects. Moving as many of them do in great flocks and spreading out over the meadows, pastures, and hillsides, as well as among the cultivated fields, they do a large amount of careful police service in arresting the culprits among insects. They even pry them out of burrows and crevices in the earth where these creatures lurk during daytime only to come forth after nightfall to destroy vegetation. The large flocks of Eskimo Curlews that formerly passed through eastern Nebraska did magnificent work during years when the Rocky Mountain Locust was with us, as did also the equally large flocks of Golden Plovers. The Bartramian Sandpiper even now is a great factor each summer in checking the increasing locusts on our prairies.

The various members of the Grouse family, while belonging to a grain-eating group, are certainly quite prominent as insect destroyers. Especially is this so with respect to the Quail, Prairie Hen, Sharptailed Grouse, and Wild Turkey, all of which are occupied most of the summer months in capturing and destroying vast numbers of such insects as are found on the prairies. Grasshoppers, locusts, crickets, caterpillars, and similar insects comprise the bulk of their insect food — forms that are all among the most numerous as well as destructive species. In writing about these

birds as insect destroyers Prof. Samuel Aughey writes: "I happened to be in the Republican Valley, in southwestern Nebraska, in August, 1874, when the locust invaded that region. Prairie chickens and quails, that previous to their coming had a large number of seeds in their stomachs, when dissected, seemed now for a time to abandon all other kinds of food. At least from this onward for a month little else than locusts were found in their stomachs. All the birds seemed now to live solely on locusts for a while." In winter and at other times of the year when insect life is scarce and difficult to obtain, these birds feed more or less extensively upon seeds and other kinds of vegetation. Some even enter cultivated grounds and seek food that belongs to the farmer, thereby doing more or less direct injury. The extent of such injury, of course, depends upon the number of birds engaged in the depredations, and also on the time over which it is allowed to extend. If corn and other grain is harvested at the proper time, but little damage ensues; but if allowed to remain in the field throughout winter, much of the crop is liable to be taken by the birds.

QUAIL.

Perhaps no other bird that frequents the farm pays higher prices for the grain it eats than does the Quail. Living about the hedgerows, groves, and ravines, where insect enemies gather and lurk during the greater part of the year, this bird not only seizes large numbers of these enemies daily during the summer months when they are "abroad in the land," but all winter through it scratches among the fallen leaves and other rubbish that accumulates about its haunts seeking for hibernating insects of various kinds. Being a timid little creature, the Quail seldom leaves cover to feed openly in the fields, and therefore does but little actual harm in the way of destroying grain. In fact it only takes stray kernels that otherwise might be lost. This bird is one of the few that feeds upon that unsavory insect, the chinch-bug; and the number of this pest that occasionally are destroyed by it is really astonishing. No farmer or fruit-grower should ever kill a quail himself nor allow anyone else to hunt it on his premises.

Our domestic fowls, save ducks and geese, from which so much direct income is derived throughout the year, belong here. It would be folly on my part to assert that they are useless to the farmer. Besides furnishing eggs and meat for the table, they are great aids in keeping down a variety of noxious insects during spring, summer, and fall.

The various species of Doves or Pigeons are not, as a rule, thought of as being especially harmful, yet repeated examinations of their stomach contents would indicate that their food seldom, if ever, consists of anything but grains and various kinds of seeds along with other particles of vegetation. The good done by these

birds as destroyers of weed seeds more than pays for the harm done by them as grain-eaters.

Recent careful study with reference to the food habits of Hawks and Owls carried on by the United States Department of Agriculture go to show that these birds, with but few exceptions, are the farmer's friends rather than his enemies. It appears that the good which they accomplish in the way of destroying mice, gophers, rabbits and other small mammals along with great quantities of noxious insects far exceeds the possible harm they do by the occasional destruction of poultry and other birds. A critical examination of the actual contents of about twenty-seven hundred stomachs of these birds showed that only six of the seventy-three species found in the United States are injurious. Three of these are so rare that they need not be considered. Of the remaining three the Fish Hawk is only indirectly injurious: hence but two remain to be considered, viz., the Sharp-shinned and Cooper's Hawks. "Omitting the six species that feed largely on poultry and game, 2,212 stomachs were examined, of which 56 per cent contained mice and other small mammals, 27 per cent insects, and only $3\frac{1}{2}$ per cent poultry and game birds."

The food habits of both the Turkey Vulture and Carrion Crow, or Black Vulture, are of such a nature that the destruction of these birds should be prohibited. In fact, in many of the states this is done by law. They live almost exclusively upon carrion or decomposing animal matter, and in this manner aid in the prevention of diseases that might result from the presence of such filth. They may, however, be the cause

of indirectly spreading hog cholera where animals that have died from this disease are left unburied or unburned.

The Cuckoos are among the few birds that habitually feed upon hairy caterpillars, such as the various "tent-making" species. They also destroy large numbers of other caterpillars, and do not object to beetles and other insects which they find among the foliage of trees. Although shy birds they are frequently seen in cities, where they do their share in protecting the shade trees from the ravages of insect defoliators.

WOODPECKER.

Taking the Woodpeckers as a family, there are few persons but who will readily admit that these birds comprise a very useful group. Feeding, in fact, as most of them do, upon the larvæ of wood-boring insects, they can readily do much greater good for the actual number of insects destroyed than if they destroyed only those that feed upon the foliage of trees. Not unfrequently will a single borer kill an entire tree if left to itself, while hundreds of foliage-feeding caterpillars of the same

size have but little effect upon the appearance, to say nothing of the health, of the same tree.

Mr. M. L. Beal, assistant in the Division of Ornithology and Mammalogy of the United States Department of Agriculture, in summing up the results obtained from the examination of six hundred and seventy-nine stomachs of these birds, writes as follows:

"In reviewing the results of these investigations and comparing one species with another, without losing sight of the fact that comparative good is not necessarily positive good, it appears that of seven species considered the Downy Woodpecker is the most beneficial." He then goes on to give the food habits based on contents of the stomachs of our most common species. "Judged by the stomach examinations of the Downy and Hairy Woodpecker and Flicker it would be hard to find three other species of our common birds with fewer harmful qualities."

The Flicker is one of our most common woodpeckers in Nebraska and does much towards keeping down a number of different kinds of insects. It is very fond of ants as a diet, in fact is partial to them, and this element forms almost half of its entire food-supply during the year. It also occasionally feeds upon the chinch-bug, as can be attested by the fact that the stomach of a specimen killed near Lincoln contained in the vicinity of one thousand of these bugs. It is also a fruit-eater to the extent of about one-quarter of its entire bill of fare, but nature, not man, furnishes the supply. It takes the wild kinds in preference to those that are cultivated.

The Whippoorwill, Night Hawk, and Swifts feed

entirely on insects, and must consequently be classed among the beneficial birds. They all capture their prey while upon the wing, and naturally destroy large numbers of troublesome kinds.

The various species of Flycatchers, as the name implies, destroy insects which they capture for the most part while on the wing. Flies and allied insects are quite prominent on their bill of fare; but these by no means are the only kinds of insects destroyed by them. Many a luckless locust, butterfly, moth or even beetle is snapped up and devoured by the different species of the family. The Bee-bird, or Kingbird as it is more frequently called, sometimes even catches bees. These latter, however, consist largely of drones, hence comparatively little harm is done.

One should be unprejudiced in order to write a fair biography of even a bird, or group of birds. To say that I am without such prejudice with reference to some of the members of the family of birds now to be considered, would be a falsehood. Still, I shall endeavor to give as unbiased testimony as possible with reference to their food-habits at least, and let the reader judge for himself as to what would be the proper treatment for these birds. Taking the family as a whole that which is made up of birds like the Crows, Ravens, Magpies, Jays, Nut-crackers, "Camp-robbers," etc., though some of them have unenviable names and reputations at least, are not at all as bad as we are sometimes requested to believe them to be.

The Crows, Ravens, Magpies, and immediate relatives are what might be termed "omnivorous" in food-habits, eating everything that comes their way. Crows,

however, have been shown to feed largely on insects, which in great measure at least, offsets the harm done in other directions. They also feed on various substances, the removal of which is for the general good.

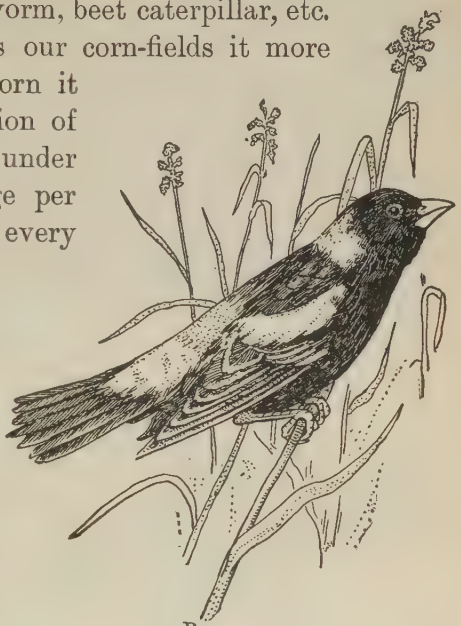
The Raven is too rare a bird in this state to be taken into consideration in respect to food-habits, and the Magpie certainly can be put out of the question of doing any possible harm for the same reason. This leaves then to be considered, the Jays, of which we seem to have six or seven distinct kinds; but only two of these are at all common. The Blue Jay is found over the entire state, and is familiar to everybody. The second species is found only in the western and north-western portions among the pine forests, and is known as the Pinon Jay or "Camp-robber" — the latter name not very flattering to the bird I must confess.

The Blue Jay does much of the mischief that is laid at the door of the Robin, orioles, thrushes, and other birds, and then sneaks away unobserved. He also destroys large numbers of insects and robs the nest of some small birds.

In the Bobolink, Meadowlark, Orioles, and Blackbirds, we have some of the most important insect destroyers among the feathered tribes. The Bobolink is with us only during the summer months when it is entirely insectivorous; and the same can be said of the Cowbird, although the latter has the bad habit of compelling other birds to rear its young.

In the Red-winged Blackbird we have a friend that we little dream of when we see the large flocks gathering about our corn-fields during late summer, and early

fall. During the balance of the year it is engaged most of the time in waging war on various insect pests, including such forms as the "grub-worms," cut-worms, grasshoppers, army worm, beet caterpillar, etc. Even when it visits our corn-fields it more than pays for the corn it eats by the destruction of the worms that lurk under the husks of a large per cent of the ears in every field.



BOBOLINK.

Several years ago the beet fields in the vicinity of Grand Island were threatened great injury by a certain caterpillar that had nearly defoliated all the beets growing in many of them. At about this time large flocks of this bird appeared and after a week's sojourn the caterpillar plague had vanished, it having been converted into bird tissues. Numerous other records of the efficiency of their labor as destroyers of insect pests might be quoted in favor of this bird, but I do not believe this to be necessary, although considerable evidence has been recorded of its destroying both fruits and grains.

The Baltimore Oriole has received such a bad reputation here in Nebraska as a grape thief during the past few years that I feel inclined to give extra time

and space in endeavoring to "clear him" of such an unenviable charge. This, however, I hardly think necessary when the facts in the case are known. As insect destroyers both this bird and the Orchard Oriole have had an undisputed reputation for many years: and the kinds of insects destroyed by both are of such a class as to count greatly in their favor. Caterpillars and beetles belonging to injurious species comprising ninety-six per cent of the food of three specimens killed is the record we have in their favor. On the other hand, grapes have been punctured only "presumably by this bird, since he has so frequently been found in the vineyard and must be the culprit." Now I myself have seen the Oriole in apple orchards under compromising circumstances, and have heard pretty strong evidence to the effect that it will occasionally puncture ripe apples. It also belongs in the same family with some generally accepted "rascals" hence I will admit that possibly some of the charges with which he is credited may be true;

Red-winged Blackbird.

but I still believe that most of the injuries to grapes in this and other states must be laid to the English Sparrow.

If we take pains to water our birds during the dry seasons they will be much less apt to seek this supply from the juices of fruits that are so temptingly near at hand. Place little pans of water in the orchard and vineyard where the birds can visit them without fear of being seized by the house cat or knocked over by a missile from the alert "small boy," and I am sure that the injury to fruit, to a great extent at least, will cease.

Recent investigations tend to prove that the Grackle or Crow-Blackbird does more good than harm and should be protected.

Our Sparrows and their allies, taken together, form a very extensive family of very beautiful as well as useful birds. Like the warblers, they occupy themselves with searching for and destroying insects all summer long; but this is not all they do that is good. In fall, winter, and early spring, when Mother Earth has lost her brilliant green and rests in sombre browns or beneath ice and snow, the longspurs, Snow Bunting, Snowbird, and some of the sparrows that have remained with us are busily engaged in gathering for themselves a living. They hop and fly about from place to place searching for and picking up little seeds of grass, grain and weeds, of shrubs and trees, and appropriating the same to their use, chirping merrily as they work away. The European House Sparrow, or the English Sparrow as it is more commonly called, has the worst reputation of the entire family. But even this bird has some redeeming traits.

The Tanagers are insect destroyers, feeding for the most part on such forms as attack the foliage of trees.

All of our Swallows are insect destroyers, capturing such forms as gnats, flies, etc., which they seize while on the wing. The large colonies of different species of these birds that breed within the state, as well as those that pass through during their migrations, destroy great numbers of these insects. They should be protected.

The Waxwings, both the Cedar Bird and Bohemian Waxwing, feed principally upon berries, etc., which they find throughout the year. Still, in his studies of the food contents of the stomachs of a variety of birds taken in a certain orchard that was overrun with canker worms, Professor Forbes found that the seven specimens of the Ceder Waxwing had eaten nothing but canker-worms and a few dung beetles, the latter in such small numbers as to scarcely count. The number of caterpillars eaten by each bird ranged from 70 to 101.

The Shrikes or "Butcher Birds" are known as veritable "brigands" or "pirates" when it comes to the destruction of other forms of life. They are true to their name, and "butcher" for pastime large numbers of insects, mice, lizards, small snakes, and even a few birds. They then fly to some thorn bush or barbed-wire fence and impale the luckless victim and leave it for future use, or to dry up and finally blow away. The good they do will outweigh the harm.

The food of the various Greenlets or Vireos is made up almost entirely of insects, of which a large per cent

are caterpillars, such as infest shade trees and the larger shrubs. They should be protected and encouraged, about the orchard in particular.

In the words of that pleasing writer, Dr. Elliott Coues,[1] "The Warblers have we always with us, all in their own good time; they come out of the south, pass on, return, and are away again, their appearance and withdrawal scarcely less than a mystery; many stay with us all summer long, and some brave the winters in our midst. Some of these slight creatures, guided by unerring instinct, travel true to the meridan in the hours of darkness, slipping past like a 'thief in the night,' stopping at daybreak from their lofty flights to rest and recruit for the next stage of the journey. Others pass more leisurely from tree to tree, in a ceaseless tide of migration, gleaning as they go; the hardier males, in full song and plumage, lead the way for the weaker females and yearlings. With tireless industry do the warblers befriend the human race; their unconscious zeal plays due part in the nice adjustment of nature's forces, helping to bring about the balance of vegetable and insect life without which agriculture would be in vain. They visit the orchard when the apple and pear, the peach, plum, and cherry are in bloom, seeming to revel carelessly amid the sweet-scented and delicately-tinted blossoms, but never faltering in their good work. They peer into the crevices of the bark, scrutinize each leaf, and explore the very heart of the buds, to detect, drag forth, and destroy those tiny creatures, singly insignificant, collectively a scourge, which prey upon the hopes of the

[1] Key to North American Birds, p. 288.

fruit-grower, and which, if undisturbed, would bring his care to naught. Some warblers flit incessantly in the terminal foliage of the tallest trees; others hug close to the scored trunks and gnarled boughs of the forest kings; some peep from the thicket, coppice, the impenetrable mantle of shrubbery that decks tiny water-courses, playing at hide-and-seek with all comers; others more humble still, descend to the ground, where they glide with pretty mincing steps and affected turning of the head this way and that, their delicate flesh-tinted feet just stirring the layer of withered leaves with which a past season carpeted the ground. We may seek warblers everywhere in the season; we shall find them a continued surprise; all mood and circumstance is theirs."

Much could be written concerning the food-habits of the various members of the group of Thrushes, Mocking-birds and Wrens. Three of the species at least are known to be more or less destructive to fruits, viz., Catbird, Brown Thrasher, and Mocking-bird. Still, if we take into account what these birds eat during the entire time spent within the state, the balance sheet stands in favor of the birds as insect destroyers. The wrens are pre-eminently insect destroyers, and the others are not much behind them in this respect.

The members of the family of Nuthatches and Tits feed for the most part on insects. But we lack very definite figures regarding the kinds and numbers of insects that each destroys. We can be sure, however, that any favors shown them will not be thrown away.

The Thrushes, Solitaires, Bluebirds, etc., are all beneficial as insect destroyers, and might be well compared with the Robin, which is described quite fully beyond, only they are even less liable to commit injuries to fruits.

The Robin has certainly been accused often enough of being a first-class rascal to warrant the belief that there must be at least some grounds for such accusations being made. In his examination of one hundred and fourteen stomachs of this bird, taken during ten months of the year, Professor Forbes, of Illinois, found the contents to consist of sixty-five per cent insects and thirty-four per cent of fruits and seeds. In the estimates of these food percentages taken by the Robin, as well as by other birds, bulk for bulk is taken, i.e., a quart of caterpillars or other insects is equivalent to a quart of cherries or a quart of berries. Professor Forbes asks this question: "Will the destruction of seventeen quarts of average caterpillars, including at least eight quarts of cut-worms, pay for twenty-four quarts of cherries, blackberries, currents, and grapes?" and then answers it in these words: "To this question I, for my own part, can only reply that I do not believe that the horticulturist can sell his small fruits anywhere in the ordinary markets of the world at so high a price as to the Robin, provided that he uses proper diligence that the little huckster doesn't overreach him in the bargain."

Much more might be said in favor of the Robin had I the time and space at my command.

After having carefully scanned the foregoing notes concerning the food-habits of our birds we cannot afford

to continue indifferent to our treatment of them, nor can we even allow our neighbors to kill them though we ourselves have decided to reform in this respect. We must work for a change of heart in our neighbors also.

THE SCISSOR BEAK

(From A Journal of Researches, etc.)

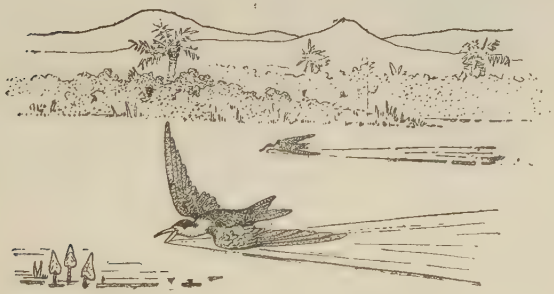
By CHARLES DARWIN.

IT has short legs, web feet, extremely long-pointed wings, and is about the size of a tern. The beak is flattened laterally, that is, in a plane at right angles to that of a spoonbill or duck. It is as flat and elastic as an ivory paper-cutter, and the lower mandible, differently from every other bird, is an inch and a half longer than the upper. In a lake near Maldonado, from which the water had been nearly drained, and which, in consequence, swarmed with small fry, I saw several of these birds, generally in small flocks, flying rapidly backwards and forwards close to the surface of the lake. They kept their bills wide open, and the lower mandible half buried in the water. Thus skimming the surface, they ploughed it in their course; the

water was quite smooth, and it formed a most curious spectacle to behold a flock, each bird leaving its narrow wake on the mirror-like surface. In their flight they frequently twist about with extreme quickness, and dexterously manage with their projecting lower mandible to plough up small fish, which are secured by the upper and shorter half of their scissor-like bills. This fact I repeatedly saw, as, like swallows, they continued to fly backwards and forwards close before me. Occasionally when leaving the surface of the water their flight was wild, irregular and rapid; then they uttered loud harsh cries. When these birds are fishing, the advantage of the long primary feathers of their wings, in keeping them dry, is very evident. When thus employed, their forms resemble the symbol by which many artists represent marine birds. Their tails are much used in steering their irregular course.

These birds are common far inland along the course of the Rio Parana; it is said that they remain here during the whole year, and breed in the marshes. During the day they rest in flocks on the grassy plains, at some distance from the water. Being at anchor, as I have said, in one of the deep creeks between the islands of Parana, as the evening drew to a close, one of these scissor-beaks suddenly appeared. The water was quite still, and many little fish were rising. The bird continued for a long time to skim the surface, flying in its wild and irregular manner up and down the narrow canal, now dark with the growing night and the shadows of the overhanging trees. At Montevideo, I observed that some large flocks during the day

remained on the mud-banks at the head of the harbor, in the same manner as on the grassy plains near the Parana; and every evening they took flight seaward. From these facts I suspect that the Rhynchops generally fishes by night, at which time many of the lower animals come most abundantly to the surface. M. Lesson states that he has seen these birds opening the shells of the mactrae buried in the sandbanks on the coast of Chile; from their weak bills, with the lower mandible so much projecting, their short legs and long wings, it is very improbable that this can be a general habit.



THE CONDOR

(From A Journal of Researches, etc.)

By CHARLES DARWIN.

THIS day I shot a condor. It measured from tip to tip of the wings eight and a half feet, and from beak to tail, four feet. This bird is known to have a wide geographical range, being found on the west coast of South America, from the Strait of Magellan along the Cordillera as far as eight degrees north of the equator. The steep cliff near the mouth of the Rio Negro is its northern limit on the Patagonian coast; and they have there wandered about four hundred miles from the great central line of their habitation in the Andes. Further south, among the bold precipices at the head of Port Desire, the condor is not uncommon; yet only a few stragglers occasionally visit the seacoast. A line of cliff near the mouth of the Santa Cruz is frequented by these birds, and about eighty miles up the river, where the sides of the valley are formed by steep

basaltic precipices, the condor reappears. From these facts, it seems that the condors require perpendicular cliffs. In Chile, they haunt, during the greater part of the year, the lower country near the shores of the Pacific, and at night several roost together in one tree; but in the early part of summer, they retire to the most inaccessible parts of the inner Cordilleras, there to breed in peace.

With respect to their propagation, I was told by the country people in Chile, that the condor makes no sort of nest, but in the months of November and December lays two large white eggs on a shelf of bare rock. It is said that the young condors cannot fly for an entire year; and long after they are able, they continue to roost by night, and hunt with their parents. The old birds generally live in pairs; but among the inland basaltic cliffs of the Santa Cruz, I found a spot, where scores must usually haunt. On coming suddenly to the brow of the precipice, it was a grand spectacle to see between twenty and thirty of these birds start heavily from their resting-place, and wheel away in majestic circles. From the quantity of dung on the rocks, they must long have frequented this place for roosting and breeding. Having gorged themselves with carrion on the plains below, they retire to these favorite ledges to digest their food. From these facts, the condor, like the gallinazo, must to a certain degree be considered as a gregarious bird. In this part of the country they live altogether on the guanacos which have died a natural death, or, as more commonly happens, have been killed by the pumas. I believe, from what I saw in Patagonia, they do not on ordinary occa-

sions extend their daily excursions to any great distance from their regular sleeping-places.

The condors may oftentimes be seen at a great height, soaring over a certain spot in the most graceful circles. On some occasions I am sure that they do this only for pleasure, but on others, the Chileno countryman tells you that they are watching a dying animal, or the puma devouring its prey. If the condors glide down, and then suddenly all rise together, the Chileno knows that it is the puma which, watching the carcass, has sprung out to drive away the robbers. Besides feeding on carrion, the condors frequently attack young goats and lambs; and the shepherd dogs are trained, whenever they pass over, to run out, and looking upwards to bark violently. The Chilenos destroy and catch numbers. Two methods are used; one is to place a carcass on a level piece of ground within an enclosure of sticks with an opening, and when the condors are gorged, to gallop up on horseback to the entrance, and thus enclose them; for when this bird has not space to run, it cannot give its body sufficient momentum to rise from the ground. The second method is to mark the trees in which, frequently to the number of five or six together, they roost, and then at night to climb up and noose them. They are such heavy sleepers, as I have myself witnessed, that this is not a difficult task. At Valpariso, I have seen a living condor sold for sixpence, but the common price is eight or ten shillings. One which I saw brought in had been tied with rope, and was much injured; yet, the moment the line was cut by which its bill was secured, although surrounded by

people, it began ravenously to tear a piece of carrion. In a garden at the same place, between twenty and thirty were kept alive. They were fed only once a week, but they appeared in pretty good health. The Chileno countrymen assert that the condor will live, and retain its vigor, between five and six weeks without eating; I cannot answer for the truth of this, but it is a cruel experiment, which very likely has been tried.

When an animal is killed in the country, it is well known that the condors, like other carrion-vultures, soon gain intelligence of it, and congregate in an inexplicable manner. In most cases it must not be overlooked, that the birds have discovered their prey, and have picked the skeleton clean, before the flesh is in the least degree tainted. Remembering the experiments of M. Audubon, on the little smelling powers of carrion-hawks, I tried in the above-mentioned garden the following experiment: the condors were tied, each by a rope, in a long row at the bottom of a wall; and having folded up a piece of meat in white paper, I walked backwards and forwards, carrying it in my hand at the distance of about three yards from them, but no notice whatever was taken. I then threw it on the ground, within one yard of an old male bird; he looked at it for a moment with attention, but then regarded it no more. With a stick I pushed it closer and closer, until at last he touched it with his beak; the paper was then instantly torn off with fury, and at the same moment, every bird in the long row began struggling and flapping its wings. Under the same circumstances, it would have been quite impossible to have

deceived a dog. The evidence in favor of and against the acute smelling powers of carrion-vultures is singularly balanced. Professor Owen has demonstrated that the olfactory nerves of the turkey-buzzard (*Cathartes aura*) are highly developed; and on the evening when Mr. Owen's paper was read at the Zoölogical Society, it was mentioned by a gentleman that he had seen the carrion-hawks in the West Indies on two occasions collect on the roof of a house, when a corpse had become offensive from not having been buried: in this case, the intelligence could hardly have been acquired by sight. On the other hand, besides the experiments of Audubon and that one by myself, Mr. Bachman has tried in the United States many varied plans, showing that neither the turkey-buzzard (the species dissected by Professor Owen) nor the gallinazo find their food by smell. He covered portions of highly offensive offal with a thin canvas cloth, and strewed pieces of meat on it; these the carrion-vultures ate up, and then remained quietly standing, with their beaks within the eighth of an inch of the putrid mass, without discovering it. A small rent was made in the canvas, and the offal was immediately discovered; the canvas was replaced by a fresh piece, and meat again put on it, and was again devoured by the vultures without their discovering the hidden mass on which they were trampling. These facts are attested by the signatures of six gentlemen, besides that of Mr. Bachman.

Often when lying down to rest on the open plains, on looking upwards, I have seen carrion-hawks sailing through the air at a great height. When the country is level I do not believe a space of the heavens, of more

than fifteen degrees above the horizon, is commonly viewed with any attention by a person either walking or on horseback. If such be the case, and the vulture is on the wing at a height of between three or four thousand feet, before it could come within the range of vision, its distance in a straight line from the beholder's eye, would be rather more than two British miles. Might it not thus readily be overlooked? When an animal is killed by the sportsman in a lonely valley, may he not all the while be watched from above by the sharp-sighted bird? And will not the manner of its descent proclaim throughout the district to the whole family of carrion feeders, that their prey is at hand?

When the condors are wheeling in a flock round and round any spot, their flight is beautiful. Except when rising from the ground, I do not recollect ever having seen one of these birds flap its wings. Near Lima, I watched several for nearly half an hour, without once taking off my eyes; they moved in large curves, sweeping in circles, descending and ascending without giving a single flap. As they glided close over my head, I intently watched from an oblique position, the outlines of the separate and great terminal feathers of each wing; and these separate feathers, if there had been the least vibratory movement, would have appeared as if blended together; for they were seen distinct against the blue sky. The head and neck were moved frequently, and apparently with force; and the extended wings seemed to form the fulcrum on which the movements of the neck, body, and tail acted. If the bird wished to descend, the wings were for a moment collapsed; and when again expanded with an altered inclination, the

momentum gained by the rapid descent seemed to urge the bird upwards with the even and steady movement of a paper kite. In the case of any bird *soaring*, its motion must be sufficiently rapid, so that the action of the inclined surface of its body on the atmosphere may counterbalance its gravity. The force to keep up the momentum of a body moving in a horizontal plane in the air (in which there is so little friction) cannot be great, and this force is all that is wanted. The movement of the neck and body of the condor, we must suppose, is sufficient for this. However this may be, it is truly wonderful and beautiful to see so great a horde, hour after hour, without any apparent exertion, wheeling and gliding over mountain and river.

THE UMBRELLA BIRD.

WOMAN'S
IMPROVEMENT CLUB
-OF-
NEWMAN, CAL.

THE UMBRELLA BIRD

(From Travels on the Amazon.)

By SIR A. R. WALLACE.

THIS singular bird is about the size of a raven, and is of a similar color, but its feathers have a more scaly appearance, from being margined with a different shade of glossy blue. It is also allied to the crows in its structure, being very similar to them in its feet and bill. On its head it bears a crest, different from that of any other bird. It is formed of feathers more than two inches long, very thickly set, and with hairy plumes curving over at the end. These can be laid back so as to be hardly visible, or can be erected and spread out on every side, forming a hemispherical, or rather a hemi-ellipsoidal dome, completely covering the head, and even reaching beyond the point of the beak: the individual feathers then stand out something like the down-bearing seeds of the dandelion. Besides this, there is another ornamental appendage on

the breast, formed by a fleshy tubercle, as thick as a quill and an inch and a half long, which hangs down from the neck, and is thickly covered with glossy feathers, forming a large pendant plume or tassel. This also the bird can either press to its breast, so as to be scarcely visible, or can swell out, so as almost to conceal the forepart of its body. In the female the crest and the neck-plume are less developed, and she is altogether a smaller and much less handsome bird. It inhabits the flooded islands of the Rio Negro and the Solimoes, never appearing on the mainland. It feeds on fruits, and utters a loud, hoarse cry, like some deep musical instrument; whence its Indian name, *Ueramimbe*, "trumpet-bird." The whole of the neck, where the plume of feathers springs from, is covered internally with a thick coat of hard, muscular fat, very difficult to be cleaned away, — which in preparing the skins, must be done, as it would putrefy, and cause the feathers to drop off. The birds are tolerably abundant, but are shy, and perch on the highest trees, and, being very muscular, will not fall unless severely wounded.

HUMMING BIRDS

(From The Naturalist in Nicaragua.)

By THOMAS G. BELT, F. G. S.

SOON after crossing the muddy Artigua below Pavon, a beautifully clear and sparkling brook is reached, coming down to join its pure waters with the soiled river below. In the evening this was a favorite resort of many birds that came to drink at the pellucid stream, or catch insects playing above the water. Amongst the last was the beautiful blue, green and white humming-bird; the head and neck deep metallic-blue, bordered on the back by a pure white collar over the shoulders, followed by deep metallic-green; on the underside the blue neck is succeeded by green, the green from the centre of the breast to the end of the tail by pure white; the tail can be expanded to a half circle, and each feather widening towards the end makes the semicircle complete around the edge. When catching the ephemeridæ that play above the water, the tail is not expanded: it is reserved for times of courtship. I have seen the

female sitting quietly on a branch, and two males displaying their charms in front of her. One would shoot up like a rocket, than suddenly expanding the snow-white tail like an inverted parachute, slowly descend in front of her, turning round gradually to show off both back and front. The effect was heightened by the wings being invisible from a distance of a few yards, both from their great velocity of movement and from not having the metallic lustre of the rest of the body. The expanded white tail covered more space than all the rest of the bird, and was evidently the grand feature in the performance. Whilst one was descending, the other would shoot up and come slowly down expanded. The entertainment would end in a fight between the two performers; but whether the most beautiful or the most pugnacious was the accepted suitor, I know not. Another fine humming-bird seen about this brook was the long-billed, fire-throated *Heliomaster pallidiceps*, Gould, generally seen probing long, narrow-throated red flowers, forming, with their attractive nectar, complete traps for the small insects on which the humming-birds feed, the bird returning the favor by carrying the pollen of one flower to another. A third species, also seen at this brook, *Petasophora delphinae*, Less., is of a dull brown color, with brilliant ear-feathers and metallic-green throat. Both it and the *Florisuga mellivora* are short billed, generally catching flying insects, and do not frequent flowers so much as other humming-birds. I have seen the *Petasophora* fly into the centre of a dancing column of midges and rapidly darting first at one end then at another secure half a dozen of the tiny flies before the column was

broken up; then retire to a branch and wait until it was re-formed, when it made another sudden descent on them. . . . I have no doubt many humming-birds suck the honey from flowers, as I have seen it exude from their bills when shot; but others do not frequent them; and the principal food of all is small insects. I have examined scores of them, and never without finding insects in their crops. Their generally long bills have been spoken of by some naturalists as tubes into which they suck the honey by a piston-like movement of the tongue; but suction in the usual way would be just as effective; and I am satisfied that this is not the primary use of the tongue, nor of the mechanism which enables it to be exerted to a great length beyond the end of the bill. The tongue, for one-half of its length, is semi-horny and cleft in two, the two halves are laid flat against each other when at rest, but can be separated at the will of the bird and form a delicate pliable pair of forceps, most admirably adapted for picking out minute insects from amongst the stamens of the flowers.

THE FOUNDATIONS OF A WONDERFUL CITY

(From The Life of the Bees.)

By MAURICE MAETERLINCK.

(Translated by Marie Josephine Welsh.)

HERE in their new home there is nothing — not a drop of honey nor a single landmark in the shape of a piece of wax. The bee has no data and no starting-point; he has nothing but the desolate nakedness of the walls and the roof of an immense building. The walls are round and smooth, but all is dark within. . . . The bee does not understand useless regrets, or if he does, he does not encumber himself with them. Far from being discouraged by the conditions which now confront him, he is more determined than ever. The hive is no sooner set up in its proper place

than the disorder of the crowd begins to diminish, and one sees in the swarming multitude clear and definite divisions which take shape in a most unexpected manner. The larger part of the bees, acting precisely like an army which is obeying the definite orders of its officer, at once begins to form thick columns along the whole length of the vertical partitions of the hive. The first to arrive at the top hang on to the arch by the claws of their hind legs, those who come after attach themselves to the first, and so on till long chains are formed which serve as bridges for the ever mounting crowd to pass over. Little by little these chains are multiplied with indefinite re-enforcements and interlacing each other become garlands, which, owing to the enormous and uninterrupted mounting of the bees upon them, are transformed into a thick triangular curtain, or rather into a sort of compact reversed cone, the point of which is attached to the top of the hive; the base of which is about two-thirds of the total height of the hive. Then the last bee, which would appear to be summoned by some interior voice

Cluster of Bees.

to join this group, mounts this curtain, which is hung in the darkness, and little by little every movement among the vast crowd ceases, and this strange reversed cone remains for many hours in a silence which might be called religious, and in a statuesqueness which in such a mass of life is almost startling, waiting for the arrival of the mystery of the wax.

While this is going on, without taking any notice of the wonderful curtain from out of whose folds so magic a gift will come, without even appearing to be tempted to attach themselves to it, the rest of the bees, that is all those who are on the floor of the hive, begin to examine the building and to undertake the work which is necessary to be done. The floor is carefully swept, dead leaves, twigs, grains of sand are transferred to a considerable distance one by one, for bees have an absolute mania for cleanliness; so much is this the case that in the winter, when the extremely cold weather prevents them from taking what bee lovers know as their "flight of cleanliness," rather than soil the interior of the hive they perish in enormous numbers, victims of a disease of the stomach.

A Bee Hive.

After this cleaning up is done these same bees set

themselves to work to carefully close up every opening which is round about the lower part of the hive. Finally when every crack has been carefully looked over, filled up and covered with propolis, they begin to varnish the whole of the interior sides. By this time guardians are placed at the entrance of the hive, and very soon a number of the working bees start on their first trip to the fields and begin to come back laden with nectar and pollen. . . .

Let us now lift up, so far as we may, one of the folds of this garlanded curtain in the midst of which the swarm is beginning to produce that strange exudation which is almost as white as snow, and is lighter than the down on a bird's breast. The wax which is now being made does not resemble at all that with which we are acquainted. It is colorless, and may be said to be imponderable. It is the very soul of the honey, which in its turn is the very spirit of the flowers, evolved by the bees in a species of silent and motionless incantation. . . .

It is very difficult to follow the various phases of the secretion and of the manner in which the wax is evolved by the swarm which is just beginning to build. The operation takes place in the midst of a dense crowd which becomes constantly more and more dense, thus producing a temperature favorable to the exudation of the wax in its first stage.

Huber, who was the first to study these operations with marvellous patience, and sometimes not without personal danger, has written more than fifty pages on the subject, but they are very confused. For myself,

as I am not writing a scientific book, I shall confine myself to describing what anybody can see if he will watch the movements of a swarm in a glass hive. At the same time I shall not fail to avail myself of Huber's studies whenever they may prove to be of service. We must admit at the very outset that the process by which the honey is transformed into wax in the bodies of this mysterious curtain of bees is still hidden in mystery. All that we know is that after about eighteen or twenty-four hours in a temperature so high that one might almost imagine there was a fire in the hive, small, white, transparent scales appear at the opening of the four little pockets which are to be found on each side of the abdomen of the bee. When the larger part of those who form the reversed cone have their abdomens decorated with these little ivory plates, one of them may be seen, as if under the influence of a sudden inspiration, to detach itself from the crowd and climb over the backs of its passive brethren until it reaches the apex of the cupola of the hive; attaching herself firmly to the top, she immediately sets to work to brush away those of her neighbors who may interfere with her movements. Then she seizes with her mouth one of the eight scales on the side of her abdomen and chews it, clips it, draws it out, steeps it in saliva, kneads it, crushes it, and makes it again into shape as dexterously as a carpenter would handle a piece of veneering. Then when the substance has been treated so as to bring it to the desired size and to the desired consistency, it is affixed to the very summit of the interior of the dome, and thus the first stone is laid of the new city, or rather the key-stone of the new

city is placed in the arch, for we are considering a city turned upside down, which descends from the sky and which does not arise from the bosom of the earth as do terrestrial cities. Then she proceeds to apply to this key-stone more of the wax which she takes from her body, and having given to the whole of her part of the work one last finishing stroke, she retires as quickly as she came and is lost in the crowd; another replaces her and immediately takes up the work where she has left it off, adds her own to it, puts that right which appears to her to be not in conformity with the general plan, and disappears in her turn, while a third and a fourth and a fifth succeed her in a series of sudden and inspired apparitions, not one of whom finishes a piece of work, but all bring to it their common share.

Now there hangs from the top of the vault a small block of wax which is yet without form. As soon as it appears to be thick enough there comes out of the group another bee bearing an entirely different aspect from that of those which have preceded it. One may well believe on seeing the certainty, the determination, with which he goes about his work and the manner in which those who stand round about him look on, that he is an expert engineer who has come to construct in space the place which the first cell shall occupy, the cell from which must mathematically depend everything which is afterwards constructed. Whatever he may be, this bee belongs to a class of the sculpturing, of chisel working bees who produce no wax and whose function seems to be to employ the materials with which the others furnish them. This bee then chooses the place of the first cell. She digs for a moment in the block of wax

which has already been placed in position, and builds up the side of the cell with the wax that she picks from the cavity. Then in exactly the same way as her predecessors have done, she suddenly leaves the work she has designed; another impatient worker replaces her and carries it on another step, which is finished by a third one. In the meantime others are working round about her according to the same method of division of labor until the outer sides of each wall is finished.

It would almost seem that an essential law of the hive was that every worker should take a pride in its work, and that all the work should be done in common, and so to speak, unanimously, in order that the fraternal spirit should not be disturbed by a sense of jealousy.

Very soon the outline of the comb may be seen. In form it is still lenticular, for the little prismatic tubes of which it is composed are unequally prolonged, and they diminish as they get away from the centre towards the extremities. At this moment it might be compared, both in form and in thickness, to a human tongue hanging down from two of the sides of the hexagonal cells which are placed back to back.

As soon as the first cells are constructed, the workers add a roof to the second and so on to the third and to the fourth. These sets of cells are divided by irregular intervals, and they are calculated in such a manner that when they are made to receive their full complement, the bees always have room enough to move about between the parallel walls of the honeycombs.

It follows then that in making their original plan the different thicknesses of every honeycomb must be fixed upon, and at the same time the alley-ways which sepa-

rate each must be different in turn, and this width must be twice the height of a bee since they have to pass each other between the upright combs.

But even the bees are not infallible, and they do not always work with exact mechanical certainty. When they find themselves in a difficult place they sometimes make very great blunders. One often finds that they leave too much, and often too little, space between the honeycombs, and they remedy these faults as well as they can — sometimes in finishing the comb which is too near another in an oblique line, or sometimes when they have left too much space they interpose a smaller comb between it.

Réamur, on this subject, says: — "Since bees sometimes make mistakes and rectify them, this must be a proof that they possess the power of reason."

Queen Bee.

It is known that bees make four different kinds of cells. There are first the "royal cells" which are exceptional and are of acorn shape. Then there are the large cells in which the male bees are reared, and in which provisions are stored when the flowers furnish forth of their abundance. Then there are the little cells which may be called the "cradles of the working bees,"

which are also employed as ordinary store-rooms. These generally occupy about eight-tenth's of the total surface of the combs in a hive; and finally there are a certain number of what may be called tran-

WORKER. DRONE.

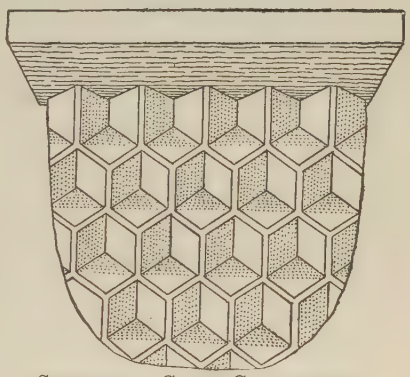
sition cells. Although these latter are inevitably irregular, the dimensions of the second or third type are so well calculated that when the decimal system was first established, and people were seeking an incontestable standard of measurement, it was the cell of the bee which was proposed first of all by Réamur. Each one of these cells is an hexagonal tube placed upon a pyramid form, and each honeycomb is formed of two strata of these tubes, base to base, in such a way that the three lozenges which make the pyramid-like base of one cell form at the same time the pyramid-like bases of the three cells on the other side.

In these prismatic tubes the honey is stored away — and so that the honey shall not trickle out as it would be likely to do if they were built strictly horizontal — they are tilted up at the outer edge of an angle of four or five degrees.

"Besides the saving in wax," says Réamur, speaking of this marvellous building, "which is effected by this

arrangement of the cells, — besides the fact that by this plan the comb may be filled without a single gap, there are other advantages in the way of the solidity thus given. . . . Every possible advantage in the way of the solidity of each cell is brought about by the manner of its construction, and by its place with reference to the rest of the cells in the comb."

"Students of geometry know," says Dr. Reid, "that there are only three shapes that can be employed to divide a surface into uniform spaces, that shall be regular in shape, and without interstices.



Section of Cells Constructed by Bees.

They are the equilateral triangle, the square, and the regular hexagon, which latter, in the matter of cell construction, is superior to the two first both from the point of view of strength and utility, and it is just this form that the bees have adopted, precisely as though its advantages were familar to them.

"Furthermore, the bottoms of the cells form three planes meeting at one point, and it has been demonstrated that both in economy of labor and material this system of construction is the best — again, the angle of the inclination of the planes affects this question of economy: this problem has been solved by the bees and confirmed by Maclaurin by abstruse mathematical calculations published in the "Transactions of the Royal Society of London."

Of course I do not suppose for a moment that the bees themselves have made these calculations, but on the other hand I do not believe that chance, or accidental circumstance has brought about these results. The wasps, for instance, have built hexagonal cells, but they have not displayed such ingenuity as the bees have done. Their combs have only one course of cells, and they have not the foundation which serves the bees for their double rows. Hence there is less strength, more irregularity, and a loss of time, of material, and of room, which really means that a quarter of the labor employed and a third of the space occupied is lost. We also find certain other domesticated bees, not so far progressed in civilization, which only build one row of cells for rearing their young, and which support horizontal combs one above another on costly columns of wax. Their food store-cells, are like a row of round pots, and the bees make but a clumsy use of the spaces between them. Indeed, when we compare their City with the Wonderful City of the bees of which we are speaking, it is like comparing a row of huts with a modern laid out city. If the result is not charming, it is severely logical, and demonstrates the genius of the race which is forever fighting to get the most out of matter, space, and time.

Buffon had a theory which has been revived once more, that the bees did not intend to make hexagonal cells, but rather round ones, and that owing to the crowding of the workers all around, the round ones became hexagonal. It is said also that crystals, fish-scales of certain kinds, soap-bubbles, etc., follow the same law, and Buffon advances this experiment to prove

it. "Take a vessel and fill it full with peas or any other round grains, pour as much water upon them as will fill the spaces between them, close the vessel tightly, and boil the water. It will be found that the round peas have become six-sided. One sees clearly that this must be so from purely mechanical causes; each one of the round grains tends in the course of swelling as it boils to fill up the utmost space that it can, and by the extension and pressure of all alike they become hexagonal. Each bee wishes to occupy as much room as possible in its allotted space, therefore as the bodies of the bees are round or cylindrical, their cells become hexagonal because of the extension and pressure of all alike."

Here then we see reciprocal obstacles working a wonder, somewhat in the same way perhaps as the vices of men bring about a general virtue, so that the race odious, often so far as individuals are concerned, is tolerable in the mass. Broughman, Kirby, and Spence and others claim that the observations of soap-bubbles and peas prove nothing in this connection, for the effect of compression is only to produce irregular hexagonal forms, and does not explain the earlier form of the base of the cells.

To this one might rejoin that there are more ways than one of dealing with the blind law of necessity, for the wasp and the bumble-bee and many other species in similar circumstances and with the same end in view, arrive at very different, and manifestly inferior, results. Indeed it might be said further that even if the bee-cells did conform to the laws of crystallization as in the case of snow, or Buffon's soap-bubbles, or boiled

peas, they show also in their general symmetry, in their well-determined angle of inclination, etc., that there are many other laws not followed by inert matter to which they also conform.

In order to assure myself that the hexagonal form of the cell was the outcome of the bee-brain, I cut out from the centre of a honey-comb a round piece not quite so large as a silver dollar, containing both brood-cells and honey-cells. I cut into this disc, at the point where the pyramidal bases of the cells were joined, and I fixed on the base of the section thus exposed a piece of tin of the same size, and so stout that the bees could not bend or twist it. Then I replaced the disc of comb, with the piece of tin as described. One side of the comb showed, of course, nothing extraordinary, but on the other side was to be seen a hole at the bottom of which was a round piece of tin occupying the place of about thirty cells. At first the bees were disconcerted, and came in crowds to examine and study this wonderful abyss; for some days they wandered about it in agitation without coming to any decision. But as I fed them well every evening, the time soon came when they needed more cells in which to store their provisions. Then most likely the famous engineers, the sculptors, and the waxmakers, were summoned to show the way to fill up this useless chasm.

A heavy curtain, or garland, of the wax-making bees covered the spot so as to develop the necessary heat; others went down into the hole and began the work of solidly fixing the metal in place by means of little claws of wax around its entire circumference, attaching them to the walls of the cells which surrounded it.

Then they set to work to make three or four cells in the upper part of the disc, attaching them to these waxen claws. Each of these new cells was more or less unfinished at the top, so as to leave material wherewith to fasten it to the next cell, but below on the piece of tin was always three very clear, and precise angles from which would grow the three upright lines which regularly marked the outline of the first half of the next cell. After about forty-eight hours, although three or four bees at most could work at the same time in the opening, the whole surface of the piece of tin was covered with the outlines of the new cells. They were certainly somewhat less regular than those in an ordinary comb. . . . But they were all perfectly hexagonal; not a line was bent, not an angle out of shape; nevertheless all the ordinary conditions of bee-life were changed. The cells were not dug out of a block of wax as Huber described, nor were they made according to Darwin, circular at first, and then made into hexagons by the pressure of their neighbors. Here was no question of reciprocal obstacles, seeing that the cells were made one by one, and these first outlines were sketched on a kind of table. It would appear therefore that the hexagonal form is not the result of any mechanical necessity, but that it forms the plan resulting from the experience, the intelligence, and the will of the bee. Another curious thing which I accidentally noticed was that the cells built upon the tin were not provided with any other floor than the tin itself. The engineers of the working party evidently reasoned that the tin was sufficient to retain the liquid honey, and that it was not necessary, therefore, to line it with wax.

But a little while after, when some honey was placed in the cell, they probably found that the metal effected some change in it, for upon taking counsel together they covered the surface of the tin with a kind of diaphanous varnish.

If we wish to throw light on all the secrets of this geometrical architecture, we shall find many more interesting questions to examine — for example, that of the form of the first cells, which are attached to the roof of the hive — a form which is modified so that the cells can fit its curve and touch the roof at the greatest possible number of points.

It would be necessary to notice also, not only the direction in which the main streets of the hive run, but the alley-ways and passages which run in and out and around the comb, as much for the circulation of the air as for the traffic; and it should be remarked that these are planned so as to avoid long detours or confusion in the traffic. . . .

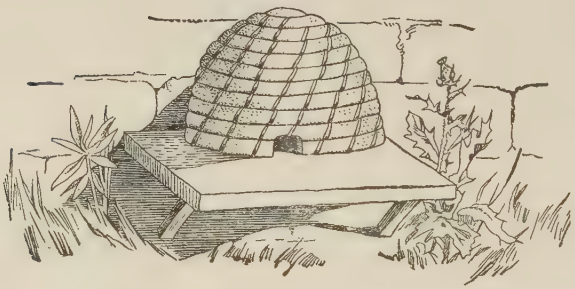
Before we leave this subject let us, only for a minute, stop to consider the wonderful and mysterious way in which the bees make their plans and work together when they are occupied in carving out their cells, on both sides of the comb, where neither can see the other. Look through one of these transparent combs, and you will see clearly and sharply cut out in this diaphanous wax a network of prisms arranged in so perfectly fitting a manner that one might think they were stamped out of steel.

Those who have never seen the inside of a hive can have little idea of the appearance of these honeycombs. Let us take a countryman's hive in which the bee has

been left free to work as he pleases. This bell-like shape is divided from top to bottom by five, six, eight, and sometimes ten, slices of wax, so to speak, perfectly parallel with each other, which take the exact shape of the curve of the walls of the hive. Between each one of these slices is a space of about half an inch in which the bees move about. When they begin to build one of these slices at the top of the hive, the wall of wax is quite thick, and hides entirely the fifty or sixty bees who are working on one side from the fifty or sixty at work on the other. Unless they have a sight which can pierce the most opaque bodies, neither can see what is doing on the other side. Nevertheless, a bee on one side does not dig a hole or add a fragment of wax which does not correspond exactly with a protuberance or a cavity on the other side. How do they contrive to do this? How does it happen that one does not dig too far, and the other not far enough?

How is it that every angle coincides in such magnificent perfection? Who tells the bee to begin here and to end there? Once again we must be satisfied with the reply that does not answer: "It is one of the mysteries of the hive." Huber has tried to explain it by saying that at certain intervals, by the pressure of their feet or their teeth, they produce a slight projection of the wax on the other side of the comb, or that they can determine the thickness of the block of wax by its flexibility, its elasticity, or some other physical property which it may possess; or, again, that their antennæ are able to serve as compasses in enabling them to examine what is going on in the darkness of the other side; or, last of all, he suggests that all the cells mathematically

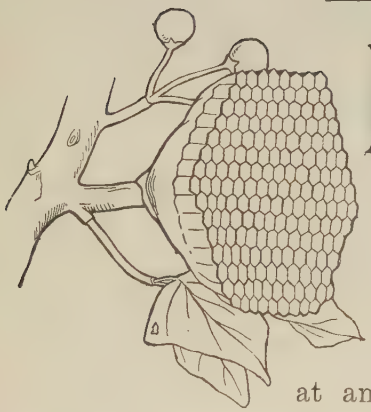
derive their shape and dimensions from those of the first row, which is built without the need of further concert on the part of the workers. But one can easily see that these explanations are not sufficient; the first are guesses which cannot be verified; the others simply change but do not remove the mystery. But if it is good to change a mystery as often as possible, it is never good to flatter one's self that to change it means to remove it!



WASPS

(From The Naturalist in Nicaragua.)

By THOMAS G. BELT, F.G.S.



I ONE day saw a small black and yellow banded wasp hunting for spiders; it approached a web where a spider was stationed in the centre, made a dart towards it — apparently a feint to frighten the spider clear of its web; at any rate it had that effect, for it fell to the ground, and was immediately seized by the wasp, who stung it, then ran quickly backwards, dragging the spider after it, up a branch reaching to the ground until it got high enough, when it flew heavily off with it. It was so small, and the spider so heavy, that it probably could not have raised it from the ground by flight. All over the world there are wasps that store their nests with the bodies of spiders for their young to feed on. In Australia, I often witnessed a wasp combating with a large flat spider that is found on the bark of trees. It would fall to the ground, and lie on its back, so as to be able to grapple with its opponent;

but the wasp was always the victor in the encounters I saw, although it was not always allowed to carry off its prey in peace. One day, sitting on the sandbanks on the coast of Hobson's Bay, I saw one dragging along a large spider. Three or four inches above it hovered two minute flies, keeping a little behind, and advancing with it. The wasp seemed much disturbed by the presence of the tiny flies, and twice left its prey to fly up towards them, but they darted away with it. As soon as the wasp returned to the spider, there they were hovering over and following it again. At last, unable to drive away its small tormentors, the wasp reached its burrow and took down the spider, and the two flies stationed themselves one on each side the entrance, and would, doubtless, when the wasp went away to seek another victim, descend and lay their own eggs in the nest.

The variety of wasps, as of all other insects, was very great around Santo Domingo. Many made papery nests, hanging from the undersides of large leaves.

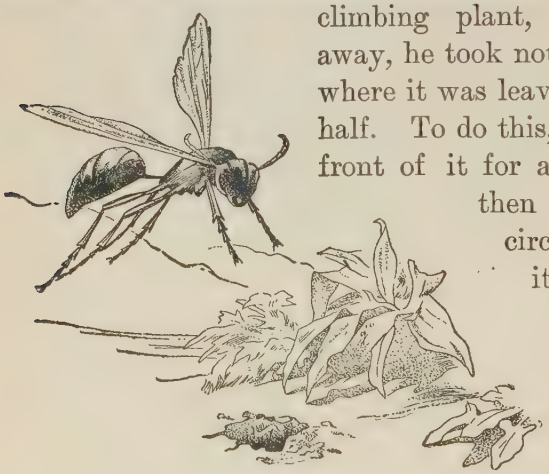
Wasps' Nest.

Others hung their open cells underneath verandahs and eaves of houses. One large black one was particularly abundant about houses, and many people got stung by them. They also built their pendent nests in the orange and lime trees, and it is not always safe to gather the fruit. Fortunately they are heavy flyers, and can

often be struck down or evaded in their attacks. They do good where there are gardens, as they feed their young on caterpillars, and are continually hunting for them. Another species, banded brown and yellow (*Polistes carnifex*), has similar habits but is not so common, Bates, in his account of the habits of the sand-wasps at Santarem, on the Amazon, gives an interesting account of the way in which they took a few turns in the air around the hole they had made in the sand before leaving to seek for flies in the forest, apparently to mark well the position of the burrow, so that on their return they might find it without difficulty. He remarks that this precaution would be said to be instinctive, but that the instinct is no mysterious and unintelligible agent, but a mental process in each individual differing from the same in man only by its unerring certainty. I had an opportunity of confirming his account of the proceedings of wasps when quitting a locality to which they wished to return, in all but their unerring certainty. I could not help noting how similar they were to the way in which a man would act who wished to return to some spot not

The Sand-Wasp.

easily found out, and with which he was not previously acquainted. A specimen of the *Polistes carnifex* was hunting about for caterpillars in my garden. I found one about an inch long, and held it out towards it on the point of a stick. It seized it immediately, and commenced biting it from head to tail, soon reducing the soft body to a mass of pulp. It rolled up about one-half of it into a ball, and prepared to carry it off. Being at the time amidst a thick mass of a fine-leaved climbing plant, before flying away, he took note of the place where it was leaving the other half. To do this, it hovered in front of it for a few seconds, then took small circles in front of it, then larger ones round the whole plant. I thought it had gone, but it returned again, and had another look at the opening in the dense foliage down which the other half of the caterpillar lay. It then flew away, but must have left its burden for distribution with its comrades at the nest, for it returned in less than two minutes, and making one circle around the bush, descended to the opening, alighted on a leaf, and ran inside. The green remnant of the caterpillar was lying on another leaf inside, but not connected with the one on which the wasp alighted,



Wasp and Hole in the Sand.

so that in running in it missed it, and soon got hopelessly lost in the thick foliage. Coming out again, it took another circle, and pounced down on the same spot again, as soon as it came opposite to it. Three small seed-pods, which here grew close together, formed the marks that I had myself taken to note the place, and these the wasp seemed also to have taken as its guide, for it flew directly down to them, and ran inside; but the small leaf on which the fragment of caterpillar lay, not being directly connected with any on the outside, it again missed it, and again got far away from the object of its search. It then flew out again, and the same process was repeated again and again. Always when in circling round it came in sight of the seed-pods down it pounced, alighted near them, and recommenced its quest on foot. I was surprised at its perseverance, and thought it would have given up the search; but not so, it returned at least half a dozen times, and seemed to get angry, hurrying about with buzzing wings. At last it stumbled across its prey, seized it eagerly, and as there was nothing more to come back for, flew straight off to its nest, without taking any further note of the locality. Such an action is not the result of blind instinct, but of a thinking mind: and it is wonderful to see an insect so differently constructed using a mental process similar to that of man. It is suggestive of the probability of many of the actions of insects that we ascribe to instinct being the result of the possession of reasoning powers.

A WASP AND ITS PREY

(From The Instincts and Habits of the Solitary Wasps.)[1]

By G. W. and E. G. PECKHAM.

MOST graceful and attractive of all the wasps — as Fabre describes them, the Ammophiles, of all the inhabitants of the garden, hold the first place in our affections. Not so beautiful as the blue *Pelopaeus* nor so industrious as the little red-girdled *Trypoxylon*, their intelligence, their distinct individuality, and their obliging tolerance of our society make them an unfailing source of interest. They are, moreover, the most remarkable of all genera in their stinging habits, and few things have

[1] Reprinted by permission from Bulletin No. 2, Series I, of The Wisconsin Geological and Natural History Survey, 1898.

given us deeper pleasure than our success in following the activities and penetrating the secrets of their lives. In our neighborhood we have but two species of *Ammophila*, *urnaria* Cresson and *gracilis* Cresson, both of them being very slender bodied wasps of about an inch in length, *gracilis* all black, and *urnaria* with a red band around the front end of the abdomen. With two exceptions our observations relate to *urnaria*.

During the earlier part of the summer we had often seen these wasps feeding upon the nectar of flowers, especially upon that of the sorrel of which they are particularly fond, but at that time we gave them but passing notice. One bright morning in the middle of July, however, we came upon one that was so evidently hunting, and hunting in earnest, that we gave up everything else to follow her. The ground was covered, more or less thickly, with patches of purslane, and it was under these weeds that our *Ammophila* was eagerly searching for her prey. After thoroughly investigating one plant she would pass to another, running three or four steps and then bounding as though she were made of thistledown and were too light to remain upon the ground. We followed her easily, and as she was in full view nearly all of the time we had every hope of witnessing the capture, but in this we were destined to disappointment. We had been in attendance on her for about a quarter of an hour when, after disappearing for a few moments under the thick purslane leaves, she came out with a green caterpillar. We had missed the wonderful sight of the paralyzer at work, but we had no time to bemoan our loss for she was making off at so rapid a pace that we were well occupied in keeping

up with her. She hurried along with the same motion as before, unembarrassed by the weight of her victim. Twice she dropped it and circled over it a moment before taking it again. For sixty feet she kept to open ground, passing between two rows of bushes, but at the end of this division of the garden, she plunged, very much to our dismay, into a field of standing corn. Here we had great difficulty in following her, since far from keeping to her former orderly course, she zigzagged among the plants in the most bewildering fashion, although keeping a general direction of northeast. It seemed quite impossible that she could know where she was going. The corn rose to a height of six feet all around us; the ground was uniform in appearance, and, to our eyes, each group of corn stalks was just like every other group, and yet, without pause or hesitation, the little creature passed quickly along, as we might through the familiar streets of our native town.

"She Hurried along, Unembarrassed by the Weight of Her Victim."

At last she paused and laid her burden down. Ah! the power that has led her is not a blind, mechanically perfect instinct, for she has travelled a little too far. She must go back one row into the open space that she has already crossed, although not just at this point.

Nothing like a nest is visible to us. The surface of the ground looks all alike, and it is with exclamations of wonder that we see our little guide lift two pellets of earth which have served as a covering to a small opening running down into the ground.

The way being thus prepared she hurries back with her wings quivering and her whole manner betokening joyful triumph at the completion of her task. We, in the meantime, have become as much excited over the matter as she is herself. She picks up the caterpillar, brings it to the mouth of the burrow and lays it down. Then, backing in herself, she catches it in her mandibles and drags it out of sight, leaving us full of admiration and delight.

How clear and accurate must be the observing powers of these wonderful little creatures! Every patch of ground must, for them, have its own character; a pebble here, a larger stone there, a trifling tuft of grass — these must be their landmarks. And the wonder of it is that their interest in each nest is so temporary. A burrow is dug, provisioned and closed up, all in two or three days, and then another is made in a new place with everything to learn over again.

From this time (July thirteenth) on to the first of September our garden was full of these wasps, and they never lost their fascination for us, although owing to a decided difference between their taste and ours as to what constituted pleasant weather all our knowledge of them was gained by the sweat of our brows. When we wished to utilize the cool hours of the morning or of the late afternoon in studying them, or thought to take advantage of a cloud which cast a

grateful shade over the sun at noonday, where were our Ammophiles? Out of sight entirely, or at best only to be seen idling about on the flowers of the onion or sorrel. At such a time they seemed to have no mission in life and no idea of duty. But when the air was clear and bright and the mercury rose higher and higher, all was changed. Their favorite working hours were from eleven in the morning to three in the afternoon, and when they did work they threw their whole souls into it. It was well that it was so, for they certainly needed all the enthusiasm and perseverance that they could muster for such wearisome and disappointing labor. Hour after hour was passed in search, and often there was nothing to show at the end of it, for, since the caterpillars that they wanted were nocturnal species, most of them were under ground in the day-time. The species observed by Fabre knew, by some subtle instinct, where to find the worm, and unearthed it from its burrow. *Urnaria*, on the contrary, never dug for her prey, but hunted on bare ground, on the purslane, and most of all on the bean-plants. These were examined carefully, the wasp going up and down the stems and looking under every leaf, but the search was so frequently unsuccessful that in estimating their work we are inclined to think that they can scarcely average one caterpillar a day. When they were hunting over bare ground they often paused and seemed to listen, and in the beginning we expected to see them burrow down and drag a victim from under the soil, but this never happened.

In this species, as in every one that we have studied, we have a most interesting variation among the dif-

ferent individuals, not only in methods but in character and intellect. While one was beguiled from her hunting by every sorrel blossom she passed, another stuck to her work with indefatigable perseverance. While one stung her caterpillar so carelessly and made her nest in so shiftless a way that her young could only survive through some lucky chance, another devoted herself to these duties, not only with conscientious thoroughness, but with an apparent craving after artistic perfection that was touching to see.

The method employed by the *Ammophilæ* in stinging their prey is more complex than that of any other predatory wasp. The larvæ with which they provision their nests are made up of thirteen segments, and each of these has its own nervous centre or ganglion. Hence if the caterpillar is to be reduced to a state of immobility, or to state so nearly approaching immobility that the egg may be safely laid upon it, a single sting, such as is given by some of the *Pompilidæ* to their captured spiders, will be scarcely sufficient. All this we knew from Fabre's "Souvenirs," and yet we were not at all prepared to believe that any plain American wasp could supply us with such a thrilling performance as that of the Gallic *hirsuta*, which he so dramatically describes. We were, however, most anxious to be present at the all-important moment that we might see for ourselves just how and where *Ammophila urnaria* stings her victim.

For a whole week of scorching summer weather we lived in the bean patch, scorning fatigue. We quoted to each other the example of Fabre's daughter Claire, whose determination to solve the problem of *Odynerus*

led to a sun-stroke. We followed scores of wasps as they hunted; we ran, we threw ourselves upon the ground, we scrambled along on our hands and knees in our desperate endeavors to keep them in view, and yet they escaped us. After we had kept one in sight for an hour or more some sudden flight would carry her far away and all our labor was lost.

At last, however, our day came. We were doing a little hunting on our own account, hoping to find some larvæ which we could drop in view of the wasps and thus lead them to display their powers, when we saw an *urnaria* fly up from the ground to the underside of a bean leaf and knock down a small green caterpillar. Breathless with an excitement which will be understood by those who have tasted the joy of such a moment, we hung over the actors in our little drama. The ground was bare, we were close by and could see every motion distinctly. Nothing more perfect could have been desired.

The wasp attacked at once but was rudely repulsed, the caterpillar rolling and unrolling itself rapidly and with the most violent contortions of the whole body. Again and again its adversary descended but failed to gain a hold. The caterpillar in its struggles, flung itself here and there over the ground, and had there been any grass or other covering near by it might have reached a place of partial safety, but there was no shelter within reach, and at the fifth attack the wasp succeeded in alighting over it, near the anterior end, and in grasping its body firmly in her mandibles. Standing high on her long legs and disregarding the continued struggles of her victim, she lifted it from

the ground, curved her abdomen under its body, and darted her sting between the third and fourth segments. From this instant there was a complete cessation of movement on the part of the unfortunate caterpillar. Limp and helpless, it could offer no further opposition to the will of its conqueror. For some moments the wasp remained motionless, and then, withdrawing her sting, she plunged it successively between the third and the second, and between the second and the first segments.

Wasp Plunging Her Sting into the Caterpillar.

The caterpillar was now left lying on the ground. For a moment the wasp circled above it and then, descending, seized it again, further back this time, and with great deliberation and nicety of action gave it four more stings, beginning between the ninth and tenth segments and progressing backward.

Urnaria, probably feeling — as we certainly did — a reaction from the strain of the last few minutes, and a relief at the completion of her task, now rested from her labors. Standing on the ground close by she proceeded to smooth her body with her long hind legs, standing in the meantime, almost on her head, with her abdomen directed upward. She then gave her face a thorough washing and rubbing with her first

legs, and not until she had made a complete and satisfactory toilet did she return to the caterpillar.

We saw *Ammophila* capture her prey only three times during the whole summer, but from these observations and from the condition of her caterpillars taken at various times from nests, her method seems to be wonderfully close to that of *hirsuta*, with just about the same amount of variation in different individuals.

Thus in our second example, she stung the first three segments in the regular order, the third, the second, and lastly (and most persistently) the first. She then went on, without a pause, to sting the fourth, fifth, sixth, and seventh, stopping at this point and leaving the posterior segments untouched. In our first example, it will be remembered, the middle segments were spared. The sting being completed, she proceeded to the process known as *malaxation*, which consists in repeatedly squeezing the neck of the caterpillar, or other victim, between the mandibles, the subject of the treatment being turned around and around so that all sides may be equally affected.

In our third case a caterpillar which we had caught was placed in front of a wasp just after she had carried the second larva into her nest. She seemed rather indifferent to it, passing it once or twice as she ran about, but finally picked it up and gave it one prolonged sting between the third and fourth segments. She then spent a long time in squeezing the neck, pinching it again and again. It was then left on the ground, and as she showed no further interest in it we carried it home for further study.

In the three captures, then, that came under our ob-

servation, all the caterpillars being of the same species and almost exactly of the same size, three different methods were employed. In the first, seven stings were given at the extremities, the middle segments being left untouched, and no malaxation was practised. In the second, seven stings again but given in the anterior and middle segments, followed by slight malaxation. In the third, only one sting was given but the malaxation was prolonged and severe.

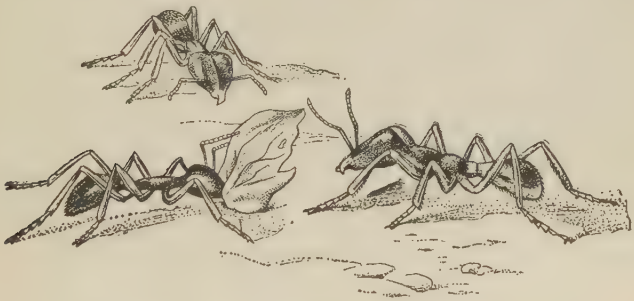
LEAF-CUTTING ANTS

(From The Naturalist in Nicaragua.)

By THOMAS G. BELT, F.G.S.

NEARLY all travellers in tropical America have described the ravages of the leaf-cutting ants (*Œcodoma*); their crowded, well-worn paths through the forests, their ceaseless pertinacity in the spoliation of the trees — more particularly of introduced species — which are left bare and ragged, with the mid-ribs and a few jagged points of the leaves only left. Many a young plantation of orange, mango, and lemon trees has been destroyed by them. Again and again have I been told in Nicaragua, when inquiring why no fruit-trees were grown at particular places, "It is no use

planting them; the ants eat them up." The first acquaintance a stranger generally makes with them is on encountering their paths on the outskirts of the forest crowded with the ants; one lot carrying off the pieces of leaves, each piece about the size of a sixpence, and held up vertically between the jaws of the ant; another lot hurrying along in an opposite direction empty handed, but eager to get loaded with their leafy burdens. If he follows this last division, it will lead him to some young trees or shrubs, up which the ants mount; and where each one, stationing itself on the



Sets off at Once on Its Return

edge of a leaf, commences to make a circular cut, with its scissor-like jaws, from the edge, its hinder-feet being the centre on which it turns. When the piece is nearly cut off, it is still stationed upon it, and it looks as though it would fall to the ground with it; but, on being finally detached, the ant is generally found to have hold of the leaf with one foot, and soon righting itself, and arranging its burden to its satisfaction, it sets off at once on its return. Following it again, it is seen to join a throng of others, each laden like itself, and, without a moment's delay, it hurries along the

well-worn path. As it proceeds, other paths, each thronged with busy workers, come in from the sides, until the main road often gets to be seven or eight inches broad, and more thronged than the streets of the city of London.

After travelling for some hundreds of yards, often for more than half a mile, the formicarium is reached. It consists of low, wide mounds of brown, clayey-looking earth, above and immediately around which the bushes have been killed by their buds and leaves having been persistently bitten off as they attempted to grow after their first defoliation. Under high trees in the thick forest the ants do not make their nests, because, I believe, the ventilation of their underground galleries, about which they are very particular, would be interfered with, and perhaps to avoid the drip from the trees. It is on the outskirts of the forest, or around clearings, or near wide roads that let in the sun, that these formicariums are generally found. Numerous round tunnels, varying from half an inch to seven or eight inches in diameter, lead down through the mounds of earth; and many more, from some distance around, also lead underneath them. At some of the holes on the mounds ants will be seen busily at work, bringing up little pellets of earth from below, and casting them down on the ever-increasing mounds, so that its surface is nearly always fresh and new-looking.

Standing near the mounds, one sees from every point of the compass ant-paths leading to them, all thronged with the busy workers carrying their leafy burdens. As far as the eye can distinguish their tiny forms, troops upon troops of leaves are moving up towards the

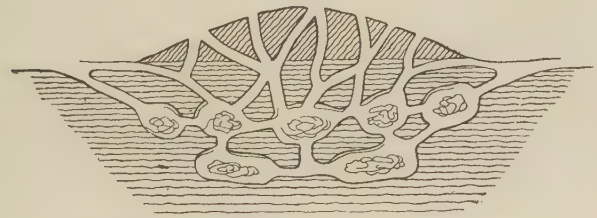
central point, and disappearing down the numerous tunnelled passages. The outgoing, empty-handed hosts are partly concealed amongst the bulky burdens of the incomers, and can only be distinguished by looking closely amongst them. The ceaseless, toiling hosts impress one with their power, and one asks — What forests can stand before such invaders? How is it that vegetation is not eaten off the face of the earth? Surely nowhere but in the tropics, where the recuperative powers of nature are immense and ever active, could such devastation be withstood.

Futher acquaintance with the subject will teach the inquirer that, just as many insects are preserved by being distasteful to insectivorous birds, so very many of the forest trees are protected from the ravages of the ants by their leaves either being distasteful to them, or unfitted for the purpose for which they are required, whilst some have special means of defence against their attacks.

These ants do not confine themselves to leaves, but also carry off any vegetable substance that they find suitable for growing the fungus on. They are very partial to the inside white rind of oranges, and I have also seen them cutting up and carrying off the flowers of certain shrubs, the leaves of which they neglected. They are very particular about the ventilation of their underground chambers, and have numerous holes leading up to the surface from them. These they open out or close up, apparently to keep up a regular degree of temperature below. The great care they take that the pieces of leaves they carry into the nest should be neither too dry nor too damp, is also consistent with

the idea that the object is the growth of a fungus that requires particular conditions of temperature and moisture to ensure its vigorous growth. If a sudden shower should come on, the ants do not carry the wet pieces into the burrows, but throw them down near the entrances. Should the weather clear up again, these pieces are picked up when nearly dried, and taken inside; should the rain, however, continue, they get sodden down into the ground, and are left there. On the contrary, in dry and hot weather, when the leaves would get dried up before they could be conveyed to the nest, the ants, when in exposed situations, do not go out at all during the hot hours, but bring in their leafy burdens in the cool of the day and during the night. As soon as the pieces of leaves are carried in they must be cut up by the small class of workers into little pieces. I have never seen the smallest class of ants carrying in leaves! their duties appear to be inside, cutting them up into smaller fragments, and nursing the immature ants. I have, however, seen them running out along the paths with the others; but instead of helping to carry in the burdens, they climb on the top of the pieces which are being carried along by the middle-sized workers, and so get a ride home again. It is very probable that they take a run out merely for air and exercise. The largest class of what are called workers are, I believe, the directors and protectors of the others. They are never seen out of the nest, excepting on particular occasions, such as the migrations of the ants, and when one of the working columns or nests is attacked, they then come stalking up, and attack the enemy with their strong

jaws. Sometimes, when digging into the burrows, one of these giants has unperceived climbed up my dress, and the first intimation of his presence has been the burying of his jaws in my neck, from which he would not fail to draw blood. The stately observant way in which they stalk about, and their great size, compared with the others, always impressed me with the idea that in their bulky heads lay the brains that directed the community in their various duties. Many of their actions, such as that I have mentioned of two relays of workmen carrying out the ant food, can scarcely be blind instinct. Some of the ants make mistakes, and



Section Through Leaf-cutting Ant's Nest.

carry in unsuitable leaves. Thus grass is always rejected by them, but I have seen some ants, perhaps young ones, carrying leaves of grass; but after a while these pieces are always brought out again and thrown away. I can imagine a young ant getting a severe ear-wigging from one of the major-domos for its stupidity.

I shall conclude this long account of the leaf-cutting ants with one more instance of their reasoning powers.

A nest was made near one of our tramways, and to get to the trees the ants had to cross the rails, over which the wagons were continually passing and repassing. Every time they came along a number of ants

were crushed to death. They persevered in crossing for some time, but at last set to work and tunnelled underneath each rail. One day, when the wagons were not running, I stopped up the tunnels with stones; but although great numbers carrying leaves were thus cut off from the nest, they would not cross the rails, but set to work making fresh tunnels underneath them. Apparently an order had gone forth, or a general understanding been come to, that the rails were not to be crossed.

SOME WONDERFUL SPIDERS

(From A Journal of Researches, etc.)

By CHARLES DARWIN.

THE number of spiders, in proportion to other insects, is here compared with England very much larger; perhaps more so than with any other division of the articulate animals. The variety of species among the jumping spiders appears almost infinite. The genus, or rather family of Epeira, is here characterized by many singular forms; some species have pointed coriaceous shells, others enlarged and spiny tibiæ. Every path in the forest is barricaded with the strong yellow web of a species belonging to the same division with the Epeira clavipes of Fabricius, which was formerly said by Sloane to make, in the West Indies, webs so strong as to catch birds. A small and pretty kind of spider, with very long forelegs, and which appears to belong to an undescribed

genus, lives as a parasite on almost every one of these webs. I suppose it is too insignificant to be noticed by the great Epeira, and is therefore allowed to prey on the minute insects, which, adhering to the lines, would, otherwise be wasted. When frightened, this little spider either feigns death by extending its front legs, or suddenly drops from the web. A large Epeira of the same division with Epeira tuberculata and conica is extremely common, especially in dry situations. Its web, which is generally placed among the great leaves of the common agave, is sometimes strengthened near the centre by a pair or even four zigzag ribbons, which connect two adjoining rays. When any large insect, as a grasshopper or wasp, is caught, the spider by a dexterous movement, makes it revolve very rapidly, and at the same time emitting a band of threads from its spinners, soon envelops its prey in a case like the cocoon of a silk worm. The spider now examines the powerless victim, and gives the fatal bite on the hinder part of its thorax; then retreating, patiently waits till the poison has taken effect. The virulence of this poison may be judged from the fact that in half a minute I opened the mesh, and found a large wasp quite lifeless. This Epeira always stands with its head downwards near the centre of the web. When disturbed, it acts differently according to circumstances: if there is a thicket below, it suddenly falls down; and I have distinctly seen the thread from the spinners lengthened by the animal while yet stationary, as preparatory to its fall. If the ground is clear beneath, the Epeira seldom falls, but moves quickly through a central passage from one side to the other. When still

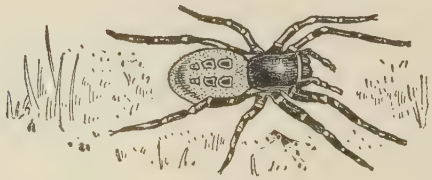
further disturbed, it practises a most curious manœuvre: Standing in the middle, it violently jerks the web, which is attached to elastic twigs, till at last the whole acquires such a rapid vibratory movement, that even the outline of the spider's body becomes indistinct.

It is well known that most of the British spiders, when a large insect is caught in their webs, endeavor to cut the lines and liberate their prey, to save their nests from being entirely spoiled. I once, however, saw in a hot-house in Shropshire a large female wasp caught in the irregular web of a quite small spider; and this spider, instead of cutting the web, most perseveringly continued to entangle the body, and especially the wings, of its prey. The wasp at first aimed in vain repeated thrusts with its sting at its little antagonist. Pitying the wasp, after allowing it to struggle for more than an hour, I killed it and put it back into the web. The spider soon returned; and an hour afterwards I was much surprised to find it with its jaws buried in the orifice, through which the sting is protruded by the living wasp. I drove the spider away two or three times, but for the next twenty-four hours I always found it again sucking at the same place. The spider became much distended by the

Four Different Spiders.

juices of its prey, which was many times larger than itself.

I may here just mention, that I found near St. Fe Bajada, many large black spiders, with ruby-colored marks on their backs, having gregarious habits. The webs were placed vertically, as is invariably the case with the genus Epeira; they were separated from each other by a space of about two feet, but were all attached to certain common lines, which were of great length, and extended to all parts of the community. In this manner the tops of some large bushes were encompassed by the united nets. Azara has described a gregarious spider in Paraquay, which Walckenaer thinks must be a Theridion, but probably it is an Epeira, and perhaps even the same species with mine. I cannot, however, recollect seeing a central nest as large as a hat, in which, during autumn, when the spiders die, Azara says the eggs are deposited. As all the spiders which I saw were of the same size, they must have been nearly of the same age. This gregarious habit, in so typical a genus as Epeira, among insects, which are so bloodthirsty and solitary that even the two sexes attack each other, is a very singular fact.



Jumping Spider.

WHAT I SAW IN AN ANT'S NEST

(From Facts and Fictions of Zoölogy.)

By ANDREW WILSON.

Nest of Termites.

AMONGST those spectacles and incidents in human existence which remain fixed on the memory of the spectator from their sad or unwonted nature, that of a panic-stricken crowd, gathered by the report of some national disaster, stands pre-eminent. Still more terrible in its details is the history of some catastrophe which has laid a city in ruins and wrought death and desolation to thousands of the inhabitants. A deadly epidemic, or fatal plague, searing a nation with its dread, mysterious power, is a calamity appalling enough; but the spectacle of a city overthrown at one fell swoop by the earthquake shock may perhaps rank foremost amongst the untoward incidents which environ the sphere of man. A certain event,

occurring during a recent holiday by the sea, tended forcibly to impress upon the mind that the great catastrophes of life are not limited to humanity's special sphere, and that in lower life panic and alarm seem to exercise no small influence, as in man's estate; whilst the incident referred to also afforded food for reflection on topics not far removed from some weighty matters in the history of man's own nature and constitution. In this latter view, it is especially hoped the observations of a brief period of leisure-time may not be without their due meed of interest.

The chance removal from its secure site, of a large stone placed in close proximity to the sea-beach, where the bliss of idleness was being fully exemplified by a small party of holiday-makers, proved, on close examination, to be the cause of a literal revolution in lower life. Imagine a city to be totally unroofed, try to conceive of the sudden downfall of houses and buildings, and the consequent panic of the inhabitants, and you may obtain an idea of the disturbance on simple procedure effected in the peaceable, well-ordered colony of ants which had located themselves securely beneath the friendly shelter of the stone. The scene presented to view was one of the most curious and interesting which could engage the attention of an observer in any field of inquiry, and the occurrence certainly banished the idle mood of the time, and lent a zest to the subsequent hours of our holiday. Running hither and thither in wild confusion were the denizens of this underground colony; their six little legs carrying their curious globular bodies backward and forward over the disturbed area from which the

stone had been removed. At first the movements of the ants were extremely erratic and purposeless. Panic and alarm appeared to be the order of the day during the few minutes which elapsed after removal of the stone. But soon the eye could discern movements of purposive kind on the part of the alarmed residents. There was "racing and chasing" in all directions: but the ants which had at first radiated from the centre of disturbance, as if on some definite quest, soon returned thereunto, and continued to advance and retire from the field of action with tolerable regularity. Not less than sixty or seventy ants appeared to be engaged in this labor of scouring the country around. The object of their repeated journeys in all directions was soon discovered. They were the self-appointed scouts, engaged in the work of reconnoitring. Such at least is a fair interpretation of the acts of the ants, and such also is the conclusion borne out by the subsequent course of events. For, after the scouts had spent a considerable time in their rapid journeys to the environments of the nest, a new set of ants appeared upon the scene, destined to perform a highly important series of labors.

The scouts continued their journeyings, and gave one the idea of a set of fussy individuals who were superintending, or even bullying, their new neighbors, who appeared from amongst the ruins and débris of the ant city, carrying in their mouths certain oval bodies of a dirty-white color, and measuring each about one-third of an inch in length. Each of these bodies closely resembled a grain of corn in shape, size, and appearance. The spectacle of these small insects carrying off these bodies in their powerful jaws impressed one forcibly

with the idea that, relatively to its size, an ant is an herculean insect.

Occasionally there might be seen certain rather ludicrous incidents connected with the removal of the objects in question. One ant might be witnessed in the endeavor to hoist the oval body it was carrying in its mouth over some obstacle lying in the path, and the staggering gait of the insect seemed very accurately to mimic the similar disposition of a human porter struggling under a burdensome load. Another ant, carrying the oval body before it, would arrive at a steep incline formed of loose sand, and presenting a treacherous surface even to the light feet of the insect. The efforts of the ant to carry the body upward being found to be fruitless, the insect might be seen to whirl about with great rapidity of action, and ascend the hill backward, pulling the body after it, instead of pushing it as before.

Another instance might be witnessed in which an ant which had literally come to grief with its burden would be assisted by a kindly neighbor; but it was no uncommon sight to behold in the excessive eagerness of the insects an actual means of defeating the object they had in view, since two ants would in some cases seize the same burden, and then came the tug of war. One pulled one way whilst the other tugged in the opposite direction; and the observer could almost have supposed that the burden itself might have been parted in twain by the treatment to which it was subjected — the incident affording a new application of the remark that a surfeit of zeal is destructive of the best intentions. The nature of the bodies which the ants

seemed so excessively anxious to preserve from injury was readily determined. The oval bodies, resembling grains of corn, were the *pupæ* or *chrysalides* of the ants — the sleeping babies and young hopefuls, on whom the hopes of the colony were, and I may say, are, founded. It is noteworthy, however, that upon some mistaken notions regarding the nature of these bodies many of the ideas concerning the frugal care of these insects were founded. Solomon's advice that the sluggard should "go to the ant," with the view of considering her ways and gaining wisdom as a result of the study, was in days of old thought to be approved by the observation that the ants husbanded their stores of food in the shape of the grains of corn they had gained from the autumnal store. There can be little doubt that some species of ants do store food; but their praiseworthy actions in this direction have been greatly exaggerated, and there appears, indeed, to be some danger of idle persons being prepared with the retort to the wise man, that the ant is by no means the model creature he thought her to be. If, however, the supposed corn-grains turn out to be the rising generation of ants in their chrysalis-state, it may be said that what the ants may have lost in the way of fame in this direction has been amply compensated for by the discovery of more wonderful traits of character than Solomon could possibly have dreamt of.

The work of removing the developing population thus appeared in our ant's nest to absorb the entire energies of the alarmed denizens. Pupa after pupa was carried out from amongst the débris and taken for a considerable distance — certainly fifteen inches — to

a place of security, beneath a small sloping stone of flat shape, which roofed over a hollow in the ground. So far as I could observe, the scouts must have discovered this place of refuge, and have communicated the intelligence to their neighbors. The regularity with which the slumbering innocents were conveyed to the same spot would appear to point to concerted work and to a definite idea, if one may so term it, having animated the laborers. I was careful to ascertain at an early stage of the proceedings that the place of refuge had no communications with the nest. It was, in point of fact, an entirely new habitation, and, as far as human judgment might venture upon an opinion, the new residence appeared to give promise of being a safe and convenient domicile. Now and then an ant would emerge from the ruins of the nest carrying a younger hopeful in the larva or caterpillar stage. This latter was a little white grub, which corresponds in its development to the grub or caterpillar of the butterfly or fly; the ants thus exemplifying insects which undergo a complete "metamorphosis." It was rather a difficult matter to ascertain clearly if the ants were actually excavating the chrysalides from amongst the débris. Bearing in mind what Sir John Lubbock has told us concerning the apparent inability of ants to discover the whereabouts of companions buried under earth, I rather lean to the belief that my ants simply conveyed to a place of safety those chrysalides which were at hand and readily obtainable. The latter fact I could not ascertain, since I feared to disturb the ants at their interesting labors; but a simple experiment served to show the feasibility of the idea

that the crysalides were probably within easy reach of the ants.

Taking possession of one chrysalis which was being conveyed to the new domicile, I buried it about half an inch deep in the sand, directly in the track over which the ants were journeying to their new residence, and a second chrysalis I placed at a little distance from this track, but in a spot over which numerous ants were running apparently without any definite aim. The second pupa ant was not buried in any sense, and was covered merely with a sprinkling of sand. The result in both cases was negative. No attempt was made to disinter the chrysalis from the beaten track, although numberless ants walked directly over it; and I extricated the chrysalis five hours after its interment, and when the busy scene of the morning had been replaced by a dull prospect, over which only a single ant now and then hurried in a rapid fashion. The other chrysalis was also unnoticed, despite its proximity to the surface of the sand. Whether or not ants want a sense of smell or other means of guiding them to the whereabouts of their neighbors or children, is a subject difficult of determination either toward a positive or negative result. And I am the more inclined to wonder at the incapacity of the insects to discover their buried companions, since they appear to be perfectly capable of detecting them at a considerable distance above ground. When a chrysalis was placed in a spot remote from the nest, and an ant placed within a foot or so of the chrysalis, the insect would occasionally seem to be attracted to the neighborhood of the object. I frequently observed that if an ant happened to crawl

within two or three inches of the chrysalis as it lay on the ground, it appeared to become conscious of the object, although at the same time it seemed ignorant of its precise locality. In such a case the insect would proceed hither and thither in an erratic fashion, but would continue to hover or rotate around the chrysalis until it seized the object and bore it off in triumph in its jaws. Relatively to the size of the ant, we must consider this latter incident by no means a slight tribute to its acuteness.

The busy scene resulting from the disturbance of the nest proceeded actively during at least two hours. The nest appeared to be by no means a large one. At the end of two hours, however, the ants were still rushing hither and thither, bent on errands unkown to their observers, although the work of conveying the chrysalides had at the lapse of the period just mentioned entirely ceased. Five and a half hours after the nest had been alarmed, not an ant was visible over the disturbed area, and our next task was that of investigating the manner in which the insects had dispersed themselves and their belongings in their new habitation by carefully removing the flat sloping stone already mentioned as that beneath which the main stream of the ants had disappeared. Not an insect was to be seen after this operation was performed, and it was only after the removal of several small stones which lay below the flat stone that the colony in its new sphere was brought into view. Our investigation once again excited the restless beings. Then ensued, for the second time, the seizure of the chrysalides, which, however, were to be seen packed together in a secure position and already

partly covered with particles of earth and sand. To have reached the position in which we found them, the insects must have descended at least three inches after entering below the stone, and the labor of the continual ascent in search of fresh chrysalides must therefore have been of no light kind. We saw enough to convince us that the ants had already settled down in a new organization, which, with an undisturbed history, might repeat the peaceful state of their former life; and we also had the thought presented, that in the exercise of their duties under the pressure of an unwonted exigency, the insect behaved and acted with no small degree of intelligence, and apparently in harmonious concert to the desired end.

But the thoughts suggested by the brief observation of the disturbed ant's nest hardly end thus. We may very naturally proceed to inquire into the regular organization and constitution of the ant colony, and also, as far as fact and theory may together lead, into the analogies — if analogies there be — which exist between the social instincts of ants and the ways of the higher animals, man included.

The common ants and their neighbors belong to the order of insects known as the *Hymenoptera*, a group represented by other insects of "social" habits, such as bees, wasps, and hornets. The termites, or white ants of the tropics, are the only "ants" foreign to this order of insects, the white ants being near relations of the dragon-flies, may-flies, etc. The family history of the latter, as told by Mr. Bates, may serve to introduce us agreeably to ant society at large. The nests of the termites may attain a height of five feet, and present the appearance

of conical hillocks, formed of earth particles "worked," says Mr. Bates, "with a material as hard as stone." In the neighborhood of the nests, narrow covered galleries or underground ways are everywhere to be seen, these latter being the passages along which the materials used for building the nests are conveyed. The termites are small soft-bodied animals of a pale color, but resemble the common or true ants in that they live in colonies, composed, like those of bees, of three chief grades of individuals. These grades are known as males, females, and blind "neuters," the latter forming at once the largest bulk of the population, and including in their numbers the true "working classes" of this curious community. In the common ants, the "neuters" are regarded as being undeveloped female insects. These neuters exhibit in the termites a further division into ordinary "workers" (Figs. 1, 4), which perform the multifarious duties connected with the ordinary life of the colony, and "soldiers" (3), which perfectly exemplify the laws of military organization in higher life, in that they have no part in the common labor, but devote themselves entirely to the defence of the colony and to the

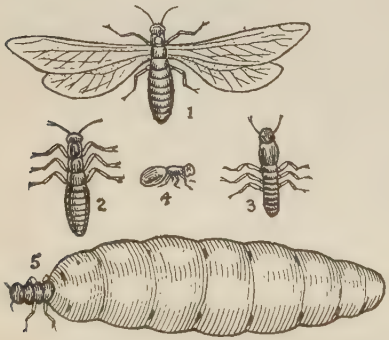


Fig. 1. 1, Winged termite; 2, wingless termite; 3, soldier; 4, worker; 5, female swollen with eggs.

"Pride, pomp, and circumstance of glorious war."

The workers appear to perform a never-ending round

of duties. They build the nests, make the roads, attend to the wants of the young, train up the latter in the ways of ant existence, wait on the sovereigns of the nest, and like diplomatic courtiers, duly arrange for the royal marriages of the future. As Mr. Bates remarks, "The wonderful part in the history of the termites is, that not only is there a rigid division of labor, but nature has given to each class a structure of body adapting it to the kind of labor it has to perform. The males and females form a class apart; they do no kind of work, but in the course of growth acquire wings to enable them to issue forth and disseminate their kind. The workers and soldiers are wingless, and differ solely in the shape and armature of the head. This member in the laborers is smooth and rounded, the mouth being adapted for the working of the materials in building the hive. In the soldier the head is of very large size, and is provided in almost every kind with special organs of offence and defence in the form of horny processes resembling pikes, tridents, and so forth. . . . The course of human events in our day seems, unhappily, to make it more than ever necessary for the citizens of civilized and industrious communities to set apart a numerous armed class for the protection of the rest; in this, nations only do what nature has of old done for the termites. The soldier termite, however, has not only the fighting instinct and function; he is constructed as a soldier, and carries his weapons not in his hand but growing out of his body." When a colony of termites is disturbed, the ordinary citizens disappear and the military are called out. "The soldiers mounted the breach," says Mr. Bates, "to cover the retreat of the

workers," when a hole was made in the archway of one of their covered roads, and with military precision the rearmen fall into the vacant places in the front ranks as the latter are emptied by the misfortune of war.

In a termite colony there is but one king and queen, the royal couple being the true parents of the colony. The state-apartments are situated in the centre of the hive, and are strictly guarded by workers. Both king and queen are wingless, and are of larger size than their subjects. The queen engages in a continual round of maternal duties, the eggs deposited by the sovereign-mother being at once seized by the workers and conveyed to special or "nursery cells," where the young are duly tended and brought up. Once a year, at the beginning of the rainy season, winged termites appear in the hive as developments of certain of the eggs laid by the queen-termite. These latter are winged males and females (Fig. 1, 1), the two sexes being present in equal numbers. Some of these, after shedding their wings, become the founders — kings and queens — of new

Fig. 2. The Queen Ant; and the Workers Carrying away the Eggs.

communities, the privilege of sex being thus associated with the important and self-denying work of perpetuating the species or race in time. Sooner or later — a termite family takes about a year to grow — a veritable exodus of the young winged termites takes place; and just before this emigration movement occurs, a hive may be seen to be stocked with "termites" of all castes and in all stages of development. The workers never exhibit a change of form during their growth; the soldiers begin to differ from the workers in the possession of larger heads and jaws; whilst the young which are destined to become the winged males and females are distinguished by the early possession of the germs of wings which become larger as the skin is successively moulted. Amongst the bees, blind Huber supposed that an ordinary or neuter egg develops into a queen bee if the larva is fed upon a special kind of food — "royal food," as it is called. Although some entomological authorities differ from Huber with regard to the exact means by which the queen bee is reared and specialized from other larvæ, yet the opinion thus expressed possesses a large amount of probability. Whatever may be the exact method or causes through or by which the queen bee is developed, Mr. Bates strongly asserts that the differences between the soldiers and worker termites are distinctly marked from the egg. This latter observer maintains that the difference is not due to variations in food or treatment during their early existence, but is fixed and apparent from the beginning of development. This fact is worthy of note, for it argues in favor of the view that if, as is most likely, the differ-

ences between the grades of termites may have originally been produced by natural selection or other causes, these differences have now become part and parcel of the constitution of these insects, and are propagated by the ordinary law of heredity. Thus acquired conditions have become in time the natural "way of life" of these animals.

Mr. Bates has also placed on record the noteworthy fact that a species of termites exists in which the members of the soldier class did not differ at all from the workers "except in the fighting instinct." This observation, if it may be used at all in elucidation of the origin of the curious family life of these insects, points not to sudden creation, but to gradual acquirement and modification as having been the method of development of the specialized classes and castes in termite society. Firstly, we may thus regard the beginnings of the further development of a colony to appear in a nest in which workers and soldiers are alike, as stated by Mr. Bates. Then, through the practice of the fighting instinct, we may conceive that natural selection would be competent to adapt the soldiers more perfectly for their duties militant, by developing the head and jaws as offensive weapons. Possibly, were our knowledge of the termites at all complete, we should meet with all stages in the development and specialization of the various grades of society amongst these insects — at least the present state of our knowledge would seem to lead to such a conclusion as being much more feasible than the theory of special or sudden creation of the peculiarities of the race. It is admitted that the termites are in many respects inferior

in structure to the bees and wasps, whilst the white ants themselves are the superiors of their own order — that of the *Neuroptera*. That the termites preceded the bees and their neighbors, the common ants, in the order of development of social instincts, is a conclusion supported by the fact that the *Neuroptera* form the first group of insects which are preserved to us in the "records of the rocks." Fossil *Neuroptera* occur in the Devonian rocks of North America; the first traces of insects allied to the bees and wasps being geologically more recent, and appearing in the oolitic strata. The occurrence of high social instincts in an ancient group of insects renders the repetition of these instincts in a later and higher group the less remarkable. The observation, however, does not of necessity carry with it any actual or implied connection between the termites and their higher neighbors, although, indeed, the likeness between the social life of the two orders of insects might warrant such a supposition.

The common ants (Fig. 3), the study of which in their native haunts is a matter of no great difficulty, and one which will fully reward the seeking mind, like the termites, possess three grades of individuals. In a single ant's nest more than one female may be found, the ants differing from the bees in this respect; and in the nests of some species of ants there are apparently "soldiers" resembling

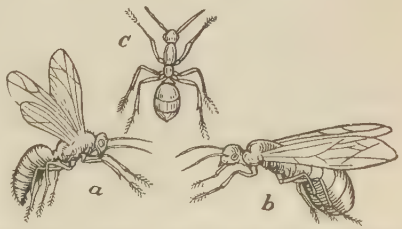


Fig. 3. Red, or Horse-Ant (*Formica rufa*). *a*, male; *b*, female, winged; *c*, worker.

the military termites in the possession of large heads and well-developed jaws. Very amazing differences are to be perceived amongst the various species of ants. Differences in size are of common occurrence, but naturalists have actually succeeded in classifying ants in a general way, by differences in manner and disposition. We know, for example, that the horse-ant (*Formica rufa*, Fig. 3) has little *individual* intelligence, but is extremely socialistic, and moves and acts *en masse* with precision and tact. Another species (*F. fusca*) is timid and retiring. *F. pratensis* is a revengeful creature, since it "worries" its fallen foes; *F. cinerea* is bold and audacious; others are termed "thieves" and "cowards"; some are phlegmatic; and to complete the list of failings and traits which are human enough in character, one species is said to present an invariable greediness as its prevailing characteristic. The common ants resemble the termites in the general details of their life. We see in an ant's nest the same restless activity of the workers, the same earnest attention paid to the young and pupæ, the same instinct in shielding the young from danger, and much the same general routine of development. Certain rather special, and it may be said extraordinary, habits of ants may, however, demand notice before we attempt a brief survey of their instincts at large. Few readers are unacquainted with the *Aphides*, or plant-lice, those little wingless insects which infest our plants and herbs in myriads in summer. It is a fact now well known to naturalists, and first placed on record by Huber, that between the ants and plant-lice, relations of a very friendly and, as far

as the ants are concerned, advantageous character have become established. Ants have been observed to stroke the tips of the bodies of the plant-lice with their antennæ, this act causing the plant-lice to exude drops of a clear, sweet fluid, of which the ants are extremely enamoured. The ants would thus appear to habitually "milk" their insect-neighbors, and, as far as observation goes, some ants seem not merely to keep the plant-lice in their nests so as to form a veritable dairy establishment, but also to make provision in the future by securing the eggs of the aphides, and bringing up the young as we rear calves.

Fig 4. Apple Aphis (*Eriosoma mali*).

That the relation between the ants and plant-lice are of very stable kind is proved by the interesting remarks of Mr. Darwin, who "removed all the ants from a group of about a dozen aphides on a dock-plant, and prevented their attendance during several hours." Careful watching showed that the plant-lice after this interval did not excrete the sweet fluid. Mr. Darwin then stroked the plant-lice with a hair, endeavoring thus to imitate the action of the ant's feelers, but not a single plant-louse seemed disposed to emit the secretion. Thereafter a single ant was admitted to their company, the insect, in Mr. Darwin's words, appearing, "by its eager way of running about, to be well aware what a rich flock it had discovered." The ant first stroked one aphis and then another, each insect excret-

ing a drop of the sweet juice "as soon as it felt the antennæ;" and "even the quite young aphides behaved in this manner, showing that the action was instinctive, and not the result of experience." If, as Mr. Darwin remarks, it is a convenience for the aphides to have the sweet secretion removed, and that "they do not excrete solely for the food of the ants," the observation does not in any degree lessen the curious nature of the relationship which has become established between the ants and their neighbors, or the interesting features in ant life which have inaugurated and perpetuated the habit.

Not less remarkable are the "slave-making" instincts of certain species of ants. It may be safely maintained that the slave-making habit forms a subject of more than ordinary interest not merely to naturalists but to metaphysicians given to speculate on the origin and acquirement of the practices of human existence. Pierre Huber, son of the famous entomologist, was the first to describe the slave-making instincts in a species (*Polyergus rufescens*) noted for its predaceous instincts, and subsequent observations have shown that other species participate in these habits. *Polyergus* is thoroughly dependent on slaves. Without these bondsmen it is difficult to see how the ants could exist. Huber tells us that the workers of this species perform no work save that of capturing slaves. Use and wont, and the habit of depending entirely on their servitors, have produced such changes in the structure of the ants that they are unable to help themselves. The jaws of these ants are not adapted for work; they are carried by their slaves from an old nest to a new one;

and, more extraordinary still, they require to be fed by their slaves, even with plenty of food close at hand. Out of thirty of these ants placed by Huber in a box, with some of their larvæ and pupæ, and a store of honey, fifteen died in less than two days of hunger and of sheer inability to help themselves. When, however, one of their slaves was introduced, the willing servitor "established order, formed a chamber in the earth, gathered together the larvæ, extricated several young ants that were ready to quit the condition of pupæ, and preserved the life of the remaining Amazons." It must be noted that there are very varying degrees in the dependence of the ant-masters on their slaves. In the recognition of this graduated scale of relationship and dependence, indeed, will be found the clue to the acquirement of this instinct. The horse-ant (*Formica rufa*) will carry off the larvæ and pupæ of other ants *for food*, and it sometimes happens that some of these captives, spared by their cannibal neighbors, will grow up in the nest of their captor. A well-known ant, the *Formica sanguinea*, found in the South of England, is however, a true slave-making species, but exhibits no such utter dependence on its servitors as does *Polyergus*. The slave-making habit is not only typically developed in the *Sanguineas*, but the bearing of the captives to their masters indicate a degree of relationship and organization such as could hardly be conceived to exist outside human experience. The *Sanguineas* make periodical excursions, and, like a powerful predatory clan, carry off the pupæ or chrysalides of a neighboring species, *F. fusca*. Thus the children of the latter race are born within the nest of their captors

in an enslaved condition. As slaves "born and bred," so to speak, they fall at once into the routine of their duties, assist their masters in the work of the nest, and tend and nurse the young of the family. The slaves, curiously enough in this instance, are black in color, whilst the masters are twice the size of the servitors, and are red in color, and that the slaves are true importations is proved by the fact that males and females of the slave species are never developed within the nest of the masters, but only within those of their own colonies. The slaves in this instance rarely leave the nest, the masters foraging for food, and employing their captives in household work, as it were; whilst, when the work of emigration occurs, the masters carry the slaves in their mouths like household goods and chattels, instead of being carried by them, as in the case of *Polyergus*.

Mr. Darwin gives an interesting account of the different attitudes exhibited by the *Sanguineas* toward species of ants other than the black race from which their slaves are usually drawn. A few pupæ of the yellow ant (*F. flava*), a courageous and pugnacious little species, were placed within the reach of the slave-making *Sanguineas*. A like chance presented with the pupæ of their slave race was eagerly seized, and the chrysalides carried off. The pupæ of the yellow ants, however, were not merely left untouched, but the slave-makers exhibited every system of terror and alarm at the sight of the chrysalides of their yellow neighbors. Such an instance demonstrates the existence not merely of perception but also of the memory of past experience, probably of not over agreeable kind, of encounters

with the yellow ants. When, on the contrary, a nest of the slaves is attacked, the *Sanguineas* are both bold and wary. Mr. Darwin traced a long file of *Sanguineas* for forty yards backward to a clump of heath, whence he perceived the last of the invaders marching homeward with a slave pupa in its mouth. Two or three individuals of the attacked and desolate nest were rushing about in wild despair, and "one," adds Mr. Darwin, "was perched motionless, with its own pupa in its mouth, on the top of a spray of heath, an image of despair over its ravaged home." The picture thus drawn is not the less eloquent because its subject is drawn from lower existence; although the pains and sorrows of ant life may not legitimately be judged by the standard of human woe.

The explanation of the slave-making instinct in ants begins with the recognition of the fact that many ants, not slave-makers, store up pupæ of other species for food. If we suppose that some of the pupæ, originally acquired through a cannibal-like instinct, came to maturity within the nest of their captors, and in virtue of their own inherited instincts engaged in the work of the hive, we may conceive of a rational beginning of the slave-making instinct. If, further, the captors learned to appreciate the labors of their captives, as lightening their own work, the habit of collecting pupæ as slaves might succeed and supersede that of collecting them for food. In any case, we should require to postulate on the part of the slave-makers a degree of instinct altogether unusual in insects, or, indeed, in higher animals; but that such instinct is developed in ants other than slave-makers admits of no dispute.

The strengthening, through repetition, of a habit useful to the species may thus be credited with the beginning of the practice of slavery amongst ants; whilst special circumstances — such as the number of the slaves as compared with the number of masters — would tend to develop a greater or less degree of dependence of the captors or their servitors.

Huber, for instance, informs us that the *Fusca*-slaves of the *Sanguineas* of Switzerland work with their masters in building the nest; they close and open the doors of the hive; but their chief office appears to be that of hunting for plant-lice. In England, on the contrary, the slaves are strictly household servants, rarely venturing out of doors. Such differences depend most probably on the fact that a greater number of slaves occur in Swiss than in English nests, and they may therefore be employed in a wider range of duties on the Continent than at home. A fewer number of slaves, a greater aptitude on the part of the slaves for their duties, the inability of the masters to perform the duties of the slaves — each or all of these causes combined would serve to increase the value of the servitors, and at the same time to reduce the independence of the masters.

This increase of the value of the slaves as active factors in the ant community might at length proceed to such extremes as we see exemplified in the *Polyergus*, already referred to — a race which has become literally unable to feed itself, and to discharge the simplest duties of ant existence, and whose actual life is entirely spent in marauding expeditions on the nests of its neighbors.

The subject of the general intelligence of ants, and of their ability to adapt themselves to awkward and unusual circumstances, may be briefly touched upon by way of conclusion.

Between the reason and intelligence of higher animals and the "instinct" of ants there is unquestionably a great gulf fixed. I make this statement unhesitatingly, notwithstanding that I should no more willingly attempt to define "instinct" than to give an exact definition of "insanity." In the latter case one may make the definition so limited as practically to exclude all save one class of cases, or so wide as to include even the judge on the bench. In the case of instinct, the rigid definition of one authority might cause us to regard it as the exclusive property of lower forms and as having no relationship whatever with the mental powers of higher beings; or, on the other hand, as being but a modified form of, or in some respects identical with, these very powers. We know too little respecting the so-called "automatic" powers and ways, even of higher animals, to dogmatize regarding the acts of lower animals, but we may safely assume that one apparent ground or distinction between instinct and reason may be found in the common incompetence of instinct to move out of the beaten track of existence, and in the adaptation of reason, through the teachings of experience, to new and unwonted circumstances. Let Dr. Carpenter speak as an authority on such a subject. "The whole nervous system of invertebrated animals, then, may be regarded as ministering entirely to *automatic* action; and its highest development, as in the class of insects, is coincident with the highest man-

ifestations of the 'instinctive' powers, which, when carefully examined, are found to consist entirely in movements of the excito-motor and sensori-motor kinds. (The terms '*excito-motor*' and '*sensori-motor*' are applied to nervous actions resulting in movements of varying kinds, and produced by impressions made on nervous centres, but without any necessary emotion, reason, or consciousness.) When we attentively consider the habits of these animals, we find that their actions, though evidently adapted to the attainment of certain ends, are very far from evincing a *designed* adaptation on the part of the beings that perform them. . . . For, in the first place, these actions are invariably performed in the same manner by all the individuals of a species, when the conditions are the same; and thus are obviously to be attributed rather to a uniform impulse than to a free choice, the most remarkable example of this being furnished by the economy of bees, wasps, and other 'social' insects, in which every individual of the community performs its appropriated part with the exactitude and method of a perfect machine. The very perfection of the adaptation, again, is often of itself a sufficient evidence of the unreasoning character of the beings which perform the work; for if we attribute it to their own intelligence, we must admit that this intelligence frequently equals, if it does not surpass, that of the most accomplished Human Reasoner."

Appealing to the most recent observations on ants, we may find evidence of the truth of Dr. Carpenter's statements, whilst at the same time we may also detect instances of the development of higher powers which

are hardly to be classed as "automatic," and which, in certain species (as in the *Ecitons*, charmingly described by Mr. Belt in "The Naturalist in Nicaragua"), may be said to be elevated above the common instincts of the race. Dr. Henry Maudsley has also well summed up the relationship of the acts of these insects to the acts of higher forms, and to new adaptations when he says: "I do not say that the ant and the bee are entirely destitute of any power of adaptation to new experiences in their lives — that they are, in fact, purely organized machines, acting always with unvarying regularity; it would appear, indeed, from close observation, that these creatures do sometimes discover in their actions traces of a sensibility to strange experiences, and of corresponding adaptations of movements. We cannot, moreover, conceive how the remarkable instincts which they manifest can have been acquired originally, except by virtue of some such power. But the power in them now is evidently of a rudimentary kind, and must remain so while they have not those higher nerve-centres in which the sensations are combined into ideas, and perceptions of the relations of things are acquired. Granting, however, that the bee or ant has these traces of adaptive action, it must be allowed that they are truly rudiments of functions, which in the supreme nerve-centres we designate as reason and volition. Such a confession might be a trouble to a metaphysical physiologist, who would thereupon find it necessary to place a metaphysical entity behind the so-called instincts of the bee, but can be no trouble to the inductive physiologist — he simply recognizes an illustration of a physiological diffusion of

properties, and of the physical conditions of primitive volition, and traces in the evolution of mind and its organs, as in the evolution of other functions and their organs, a progressive specialization and increasing complexity."

The recently published experiments of Sir John Lubbock show that ants under certain circumstances are both stupid and devoid of any intelligent comprehension in the way of surmounting difficulties; but this distinguished observer has also shown that as regards communication between ants, and in the regulation of the ordinary circumstances of their lives, these insects evince a high degree of intelligence, and exhibit instincts of a very highly developed kind. Still, making every allowance for the development of extraordinary mental power in some species of ants, there can be little doubt of the purely automatic beginnings and nature of most, if not all, of the acts of ordinary ant existence. The young ant, wasp, or bee, will begin its labors and discharge them as perfectly at the beginning of its existence as a perfect insect, as at the close of life. Here there is no experience, no tuition, no consciousness, no reason, and no powers save such as have been transferred to the insect as a mere matter of heredity and derivation from its ancestors, who lived by an unconscious rule of thumb, so to speak. It is very hard at first to convince one's self, when watching an ant's nest, that intelligence and consciousness play little or no part in the apparently intelligent operation of these insects. But to assume the contrary would be to maintain that the insect stands on an equal footing to man himself, and for such a supposi-

tion there is neither lawful ground nor sympathy. The marvellous instinct of lower life stands on a platform of its own, has its own phases of development, and probably its own unconscious way of progress. The higher reason and intellect of humanity similarly possesses its own peculiar standard, rate, and method of culture. A man may seek and find in the ways of lower existence not merely a lesson in the ordering of his existence, but some comfort, also, in the thought that the progress of lower nature is not unknown in the domain of human hopes and aspirations.

Return of Ants after a Battle.

THE WILD LLAMA

(From A Journal of Researches, etc.)

By CHARLES DARWIN.

Head of Guanaco.

THE guanaco, or wild llama, is the characteristic quadruped of the plains of Patagonia; it is the South American representative of the camel in the East. It is an elegant animal in a state of nature, with a long slender neck and fine legs. It is very common over the whole of the temperate parts of the continent, as far south as the islands near Cape Horn. It generally lives in small herds of from half a dozen to thirty in each; but on the banks of the St. Cruz we saw one herd which must have contained at least five hundred.

They are generally wild and extremely wary. Mr. Stokes told me, that he one day saw through a glass a herd of these animals which evidently had been

frightened, and were running away at full speed, although their distance was so great that he could not distinguish them with his naked eye. The sportsman frequently receives the first notice of their presence, by hearing from a long distance their peculiar shrill neighing note of alarm. If he then looks attentively, he will probably see the herd standing in a line on the side of some distant hill. On approaching nearer, a few more squeals are given, and off they set at an apparently slow, but really quick canter, along some narrow beaten track to a neighboring hill. If, however, by chance, he abruptly meets a single animal, or several together, they will generally stand motionless and intently gaze at him; then perhaps move on a few yards, turn round, and look again. What is the cause of this difference in their shyness? Do they mistake a man in the distance for their chief enemy the puma? Or does curiosity overcome their timidity? That they are curious is certain; for if a person lies on the ground, and plays strange antics, such as throwing up his feet in the air, they will almost always approach by degrees to reconnoitre him. It was an artifice that was repeatedly practised by our sportsmen with success, and it had moreover the advantage of allowing several shots to be fired, which were all taken as parts of the performance. On the mountains of the Tierra del Fuego, I have more than once seen a guanaco, on being approached, not only neigh and squeal, but prance and leap about in the most ridiculous manner, apparently in defiance as a challenge. These animals are very easily domesticated, and I have seen some thus kept in northern Patagonia near a house, though not under

any restraint. They are in this state very bold, and readily attack a man by striking him from behind with both knees. It is asserted that the motive for these attacks is jealously on account of their females. The wild guanacos, however, have no idea of defence; even a single dog will secure one of these large animals, till the huntsman can come up. In many of their habits they are like sheep in a flock. Thus when they see men approaching in several directions on horseback, they soon become bewildered, and know not which way to run. This greatly facilitates the Indian method of hunting, for they are thus easily driven to a central point, and are encompassed.

The guanacos readily take to the water: several times at Port Valdes they were seen swimming from island to island. Byron, in his voyage, says he saw them drinking salt water. Some of our officers likewise saw a herd apparently drinking the briny fluid from a salina near Cape Blanco. I imagine in several parts of the country, if they do not drink salt water, they drink none at all. In the middle of the day they frequently roll in the dust, in saucer-shaped hollows. The males fight together; two one day passed quite close to me, squealing and trying to bite each other; and several were shot with their hides deeply scarred. Herds sometimes appear to set out on exploring parties; at Bahia Blanca, where, within thirty miles of the coast, these animals are extremely unfrequent, I one day saw the tracks of thirty or forty, which had come in a direct line to a muddy salt-water creek. They then must have perceived that they were approaching the sea, for they had wheeled with the regularity of

THE GUANACO

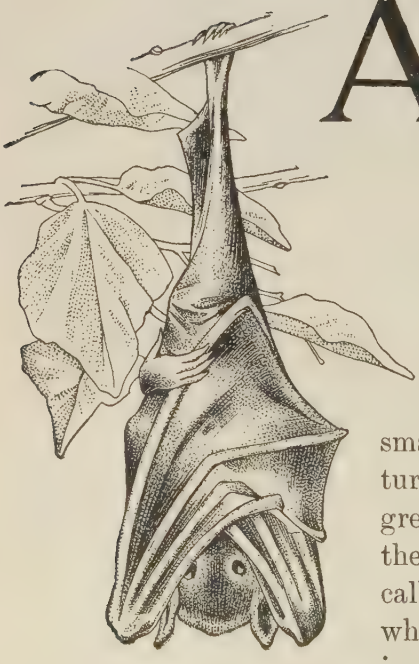
cavalry, and had returned back in as straight a line as they had advanced. The guanacos have one singular habit, which is to me quite inexplicable; namely, that on successive days they drop their dung in the same defined heap. I saw one of these heaps which was eight feet in diameter, and was composed of a large quantity. This habit, according to M. A. d'Orbigny, is common to all the species of the genus; it is very useful to the Peruvian Indians, who use the dung for fuel, and are thus saved the trouble of collecting it.

The guanacos appear to have favorite spots for lying down to die. On the banks of the St. Cruz, in certain circumscribed spaces, which were generally bushy and all near the river, the ground was actually white with bones. On one such spot I counted between ten and twenty heads. I particularly examined the bones; they did not appear, as some scattered ones which I have seen, gnawed or broken, as if dragged together by beasts of prey. The animals in most cases must have crawled, before dying, beneath and amongst the bushes. Mr. Byron informs me that during a former voyage he observed the same circumstances on the banks of the Rio Gallegos. I do not at all understand the reason of this, but I may observe, that the wounded guanacos at the St. Cruz invariably walked towards the river. At St. Jago in the Cape de Verd islands, I remember having seen in a ravine a retired corner covered with bones of the goat; we at the time exclaimed that it was the burial-ground of all the goats in the island.

BATS

(From Studies of Animated Nature.)

By W. S. DALLAS, F.L.S.



Sleeping Bat.

AMONG the sounds which greet the ear of the wayfarer as the shades of evening deepen into night, one of the commonest is a rather faint chirping noise which comes mysteriously from overhead. On looking up in search of the source of this peculiar sound, we may see a small, dark, shadow-like creature sweeping to and fro with great rapidity. It is one of the curious groups of animals called Bats, representatives of which are to be met with in in all countries, always active at night or in the twilight, and presenting a remarkable general similarity of structure, although in some respects they may differ

considerably in habits. In the British Islands some fourteen species have been distinguished.

Like the owls, with which they share the dominion of the evening air, the Bats have a perfectly noiseless flight; their activity is chiefly during the twilight, although some species are later, and in fact seem to keep up throughout the whole night. As they rest during the day, concealed usually in the most inaccessible places they can find, and are seen only upon the wing, their power of flight is their most striking peculiarity in the popular mind, and it is perhaps no great wonder that by many people, both in ancient and modern times they have been regarded as birds. Nevertheless, their hairy bodies and leathery wings are so unlike anything that we ordinarily understand as pertaining to a bird, that opinion was apparently always divided, as to the true nature of these creatures — "a mouse with wings," as Goldsmith called it once, according to James Boswell, is certainly a curious animal, and very difficult to classify so long as the would-be systematist has no particularly definite ideas to guide him. The likeness of the Bat to a winged mouse has made itself felt in the name given to the creature in many languages, such as the "Chauve-souris" of the French and the "Flitter-mouse" of some parts of England, the latter being reproduced almost literally in German, Dutch, and Swedish, while the Danes called the Bat a "Flogenmues," which has about the same meaning, and the Swedes have a second name, "Lädermus," evidently referring to the texture of the wings, as well as to the mouse-like character of the body.

But so soon as we have definite characters to appeal to in classification, we find no difficulty in assigning these puzzling creatures to their proper place in the system. Bats produce their young alive, and suckle them; the milk being produced by special glands. Now, these are characters which are peculiar among all animals to the vertebrate class Mammalia. They possess also other characters that are unmistakably mammalian. Leaving out of consideration the structure of the internal organs, they have teeth implanted in sockets in the jaws, four limbs, and a hairy covering to the skin, so that they possess more decidedly mammalian characters than some other members of the class, such as the marine whales and dolphins (*Cetacea*) and manatees (*Sirenia*), which are still often spoken of as fishes. In point of fact, although organized for flight, the Bat may, without any violence to language, be spoken of as a *quadruped*, for its fore-limbs contain all the parts found in those of other mammals fully developed, and they come into use when the creature is walking on the ground.

Perhaps the special characteristics of the Bats will be brought out most distinctly by a comparison of their structure with that of a bird, seeing that the modification of the fore-limbs into wings is their most striking distinction from other Mammalia; for, although some other members of the class are spoken of as "flying," such as the Flying Squirrels, Flying Lemurs, and Flying Phalangers, these creatures do not really fly, but merely glide through the air to considerable distances by the action of a broad fold of skin which runs down each side of the body, and

which, when stretched between the extended limbs, buoys the creatures up in the air after the fashion of a parachute.

Most of us must have had occasion to pick the bones of a bird's wing, a piece of practical anatomy which may serve us in good stead at present. They consist of a long bone, which may be called the arm-bone (*humerus*), jointed to the shoulder-bones (the so-called "side-bones" of a fowl or turkey), followed by a pair of parallel bones constituting the fore-arm, at the end of which we find two or three small bones, then two parallel bones united at their extremities, and some smaller joints terminating the whole.

We need say nothing about the arm-bone and the two bones of the fore-arm, the peculiarity of bird-structure lying chiefly in the terminal portion of the limb, or the hand. Here we find, after two little bones forming the wrist, a pair of long bones as above described, firmly united both at base and apex, and on the outside of the base of these, close to the wrist, a small bone, which may be either free or soldered to the others, and which represents the thumb in the human hand. At the other end of the piece formed by the two united bones, the limb is continued by two joints, forming a second finger, inside of which there is usually a single small bone, representing a third finger. But all these parts are stiffly attached to one another, admitting of very little motion, so that the whole hand forms as it were a single piece. The bony structure of the bird's wing is in point of fact a rod hinged in two places, at the elbow and the wrist, for the convenience of being folded into a small compass. The

flight of the bird is effected by the agency of a number of stiff feathers implanted in the skin covering the bones and muscles of the arm and hand; these fold together like the sticks of a fan when the wing is folded, and are spread into an elastic instrument for striking the air when the different sections of the bony framework are extended by the action of their respective muscles.

In the Bat the structure is very different. Of course, as in the Vertebrata generally, we find in the Bat's fore-limb the same three main sections as in birds; and as the function of the limb is the same, and a certain stiffness is necessary in the extended organ, the movements of the joints at the elbow and wrists are hinge-like. But the bones of the arm and fore-arm are longer and more slender, especially the latter; and in this part, in place of the two parallel bones of the bird's wing, we find in the Bat only a single long bone representing the smaller bone of the bird, the larger one being usually reduced to very small dimensions, and firmly united with the other into a single piece, although it still forms the elbow-joint. At the other end of this long fore-arm we find some small wrist-bones and to these the fingers are articulated. In birds, as we have seen, only two or three fingers are represented, and these are more or less reduced in size, and the most important of them soldered together; Bats, on the contrary, show the whole five fingers as distinctly as in the hand of man or any other mammals. The first of them, or the *thumb*, is short, slender, and flexible, and composed of three joints; the other four are very long and slender,

but chiefly composed of the metacarpal bones, corresponding to those of the palm of the human hand. The first, or index finger, indeed, in many Bats, consists of this bone alone; but in the others it is followed by two or three slender joints, gradually tapering to the extremity, the second finger, corresponding to our middle finger, being always the longest of all.

Just as is the bird's wing, these various parts can be folded together or extended by the action of the muscles, but in the Bat the long fingers become separated when the wing is stretched out, and by this action they at the same time stretch a thin leathery double membrane in which they are enclosed, which is thus converted into a broad surface for striking the air in flight. This membrane is continued from the fingers to the sides of the body, and even to the hind limbs, which are often included in it to the ankle-joints; while in the great majority of Bats there is even a further portion of membrane between the hind legs, enclosing the whole or a portion of the tail. There is usually also a narrow strip of the same membrane in front of each arm, so that the skin of the animal is extended as much as possible, in order to give it support in its aërial evolution. It is to be noted that the long second finger extends to the extreme point of the wing and that the first finger runs close beside it and thus assists in stiffening that part of the organ. The thumb is left free, and is furnished with a rather strong hooked claw.

Supported by the action of these great leathery wings, the Bat flies about almost incessantly during the twilight, and often late into the night. In full

career its flight is swift, though perfectly noiseless, and it has the power of executing rapid turns and changes of direction with the greatest facility, as required for the capture of its prey, which, in the great majority of cases, consists of the insects of various kinds that in most places fly by night. In pursuit of these, the Bats flit rapidly about trees, houses, and other buildings, now and then resting by clinging for a moment to the rough surfaces of the walls or the trunks and branches of trees. Old country church-yards, which are usually full of trees, are naturally favorite haunts of these nocturnal insect-hunters, offering them an excellent field for the chase of their prey, while at the same time, the church itself, with its architectural peculiarities, usually affords them a safe retirement during the day in the dark and secluded corners of its structure. Hence in the popular mind the Bat has long been associated with the church-yard, that spot so dreaded that few can pass through it after nightfall without experiencing certain peculiar feelings, so that it is no great wonder if a portion of the superstitious fear thus engendered has transferred itself to these frail and harmless creatures, and given them and their companions, the owls, something of an evil reputation. And it must be confessed that when seen against the light, flitting silently overhead, there is something weird in the Bat's form, and this is no doubt the reason why, while angels of all kinds are represented with birds' wings, those of Bats have, by universal consent, always been conferred upon demons, dragons, and similar uncanny creatures.

When it descends from its flight upon the ground or

any solid body, the Bat becomes to all intents and purposes a genuine quadruped. The fingers being drawn together, with the membranes of the wings thrown into folds between them, the whole hand of the creature is brought up parallel to the fore-arm, and so got out of the way, and the animal can then walk more or less easily, its hind legs, though short and rather feeble, being perfectly formed, and the fore limbs, from which the thumbs with their sharp claws now project freely, becoming available for terrestrial progression. Nevertheless, this progression is generally rather clumsy, as indeed might be expected from creatures so curiously constructed.

While on the wing, our Bats are constantly engaged in the pursuit of the numerous insects of various kinds which, like themselves, are active in the evening and after dark, and of these they must destroy immense quantities. The swarms of delicate gnats and midges which disport themselves in the most complicated aërial dances, moths of all kinds, and even the hard-shelled beetles, many of which fly about in the evening or at night, fall a prey to these leathern-winged rovers of the night air, and weak as the latter would seem to be, some of them are able to seize and devour beetles which appear to be far beyond their powers. Thus, the largest of our British species, the Great Bat, or Noctule (*Scotophilus noctula*), which, however, is only about three inches in length, preys freely upon such large and hard-shelled insects as cockchafers; these, in fact, appear to be its favorite food, and for their consumption its broad and comparatively strong jaws would seem to be specially fitted, while its large and

powerful wings, measuring fourteen or fifteen inches from tip to tip when expanded, enable it to fly with the rapidity necessary for the pursuit and capture of such powerful prey. When thus engaged, the Noctule haunts the neighborhood of trees, and generally flies at a considerable elevation, from which, however, his shrill cry easily reaches the ear of the passer-by. His addiction to large prey gives rise to a curious movement, thus noticed by Professor Bell in his valuable book on "British Quadrupeds." "An observer will not watch his movements long," says the Professor, "without noticing a manœuvre which at first looks like the falling of a tumbler-pigeon, but on closer examination proves to be simply a closing of the wings, and a consequent drop of about a foot. Sometimes this is repeated every few yards, as long as in sight. It is occasioned by some large and intractable insect having been captured, and the anterior joint of the wing, with its well-armed thumb, is required in retaining it until masticated." Notwithstanding this little difficulty, however, the Noctule is pretty rapid in disposing even of his most recusant prey, as he has been known to consume as many as thirteen cockchafers one after another.

The foregoing statements apply to all our British Bats, and indeed, in the matter of food and general habits, to the great majority of the species of the order, in whatever country they may occur. But in the tropical and sub-tropical regions of the eastern hemisphere, we find a great and important group of Bats, which, although agreeing in general structure and habits with our European species, differ from them altogether in

The Vampire Bat

their diet. These Bats, distinguished generally, among other things, by their larger size and more robust construction, and by certain characters of the molar teeth (grinders), from the ordinary Bats, are almost exclusively confined to a fruit diet, in search of which they fly vigorously, often in flocks, like birds, at the commencement of the night. From this peculiarity of their food they are commonly known as Fruit Bats, while the larger species, such as the Indian Fruit Bat and the Kalong of the Eastern Archipelago, which are respectively eleven and fourteen inches in length, are sometimes called Flying Foxes, in allusion to the prevalence of a reddish tint in their fur, and their more or less lengthened and dog-like muzzles. In many parts of the Eastern world, in India, the Malayan Archipelago, Australia, Africa, and even in outlying islands at some distance from their main range, these Fruit Bats occur in great numbers. Swarms of them roost together during the day, hanging from the branches of the trees which they select as their regular resting-place, and taking wing at sunset, fly off frequently to great distances in search of their favorite articles of food; for they by no means devour indiscriminately any kind of fruit, but show a distinct preference for particular sorts, generally selecting such as are also prized by their human competitors. Hence they often do considerable damage in plantations of fruit trees, as when they meet with articles that suit taste, they seem, like some human gourmands, not to know when to leave off eating. Of one of the smaller Indian species, the Margined Fruit Bat, Mr. Dobson obtained a living specimen in Calcutta, and he gives the following account

of its voracious appetite: — He gave it "a ripe banana, which, with the skin removed, weighed exactly two ounces. The animal immediately, as if famished with hunger, fell upon the fruit, seized it between the thumbs and the index fingers, and took large mouthfuls out of it, opening the mouth to the fullest extent with extreme voracity. In the space of three hours the whole fruit was consumed. Next morning the Bat was killed, and found to weigh one ounce, half the weight of the food eaten in three hours! Indeed, the animal when eating seemed to be a kind of living mill" — so continuously does its food pass through it.

From the statements of some writers, it would appear that although these Bats live chiefly upon fruits, they occasionally, like many other frugivorous animals, diversify their diet with animal food, devouring insects of various kinds, caterpillars, birds' eggs, and even young birds, while there seems to be some reason to believe that one species even feeds upon shell-fish which it picks up upon the seashore.

The fruit-eating Bats of this group are not found in the warmer parts of America, but some American Bats feed chiefly upon fruits, while many of the large essentially insectivorous species which occur there vary their diet more or less with fruits, and also occasionally attack and devour other vertebrate animals. Some of them — but it is still very doubtful how many — have another habit connected with their feeding, which renders them very decidedly objectionable, namely, that of inflicting wounds upon birds and mammals, even including man himself, and sucking up the blood that flows from them. This charge has been brought

against many Bats of South and Central America, some of which have been commonly named Vampires in consequence, after the ghostly blood-suckers, which were formerly the objects of so much superstitious terror in Hungary and other parts of Eastern Europe; but so far as can be made out from a consideration of the evidence, a verdict of "not proven," at all events, must be arrived at in the case of all but two species, which constitute a little group distinguished by what is apparently a special organization adapting them to this peculiar diet. These wretched little beasts, which only measure two and a half or three inches in length, are furnished in the upper jaw with a single pair of incisor or front teeth, but these are of great size and strength, triangular in form, and so excessively sharp that when the creatures are seized they can draw blood from the hand of their captor by what seems a mere touch. This extreme sharpness of their weapons enables them, when attacking sleeping men or animals, to slice off a small portion of skin almost without causing any pain, and the little oval wounds thus produced, like the similar surface-cuts which a careless shaver sometimes inflicts upon his chin, bleed with particular freedom. The Desmodonts, as these true Vampires are called, will attack horses, mules, and cattle, which they generally wound on the back, near the spine, often in the region of the withers; and they also bite the combs of domestic fowls, and any part of the human body that they can get at. In the case of man, however, according to most authorities, the extremity of the great toe is the favorite part; and some writers, perhaps possessed of a strong poetical vein, have given wonderful

descriptions of the artfulness with which these little blood-suckers make their approaches, and keep their victim comfortably asleep during the operation by fanning him with their wings. In fact, the Vampire Bats had so bad a reputation from the accounts given by travellers, that they seemed to be veritable scourges of the countries in which they live, but so far as can be made out from the most trustworthy reports, the mischief they cause may be summed up under two heads, namely, weakness produced by loss of blood, which continues to flow from the wounds long after the Bats have drunk their fill and gone quietly home to rest, and inflammatory affections, caused either by the irritation of the bite in the case of people of a bad habit of body, or by the friction of the saddle or collar upon the part bitten in the case of horses and mules, or of the shoe in the human patient. That the Desmodonts do really feed on blood is proved by evidence of various kinds. They have been captured in the act of blood-sucking, when their stomachs, which are peculiarly constructed and very long, are found filled with a black paste, which is evidently half-digested blood; and their teeth, which are in part so well adapted for producing the necessary wounds in other animals, are totally unfit for the mastication of an insect prey, such as constitutes the diet of their nearest allies.

After all this feeding, Bats, whatever the nature of their diet, not unnaturally find themselves inclined for repose, and as they are active during the night or in the twilight, of course their rest has to be taken in the daytime. To pass the period of repose in security they seek shelter of various kinds, not only for protection

against the weather, but also for the sake of concealment from other predaceous animals, some of which would no doubt be perfectly willing to make a meal of them. The great Eastern Fruit Bats, trusting perhaps to their size and strength, are content to resort to the branches of trees, from which, after the manner of Bats in general, they suspend themselves by the hind feet with the head downwards. From the statements of various writers it appears that after being out all night in search of food, the Flying Foxes and other allied Bats fly back to their regular resting-places, where they begin to arrive about or soon after dawn. The number resorting to the same retreat is usually so great that the whole of the branches are loaded with them, and in fact they are so crowded together that the settling down of the flock into their repose is preceded by a scene of squabbling and quarrelling of the most noisy description. Mr. Tickell, speaking of the common Indian Flying Fox, says: — "From the arrival of the first comer, until the sun is high above the horizon, a scene of incessant wrangling and contention is enacted among them, as each endeavors to secure a higher and better place, or to eject a neighbor from too close vicinage. In these struggles the Bats hook themselves along the branches, scrambling about hand over hand with some speed, biting each other severely, striking out with the long claw of the thumb, shrieking and cackling without intermission. Each new arrival is compelled to fly several times round the tree, being threatened from all points; and when he eventually hooks on, he has to go through a series of combats, and be probably ejected two or three times, before he

makes good his tenure." This scene of selfish contention over, the Fruit Bats pass some hours in profound sleep, during which they remain suspended in rows along the branches, to which they cling by one foot only, the other with all the lower surface of the body being comfortably wrapped in the leathery mantle formed by the contracted wings. In this condition, as Dr. Horsfield says of the Great Kalong, "ranged in succession with the head downwards . . . and often in close contact, they have little resemblance to living beings, and by a person not accustomed to their economy are easily mistaken for a part of the tree, or for a fruit of uncommon size suspended from its branches." In this position the head is folded down upon the breast. Dr. Bennett and Mr. Gould ascribed very similar habits to a large Fruit Bat common in the northern parts of New South Wales and in Queensland, which is said to be often exceedingly destructive to the peach and other fruit crops of the settlers in those colonies.

The European Bats, and indeed all the Bats except these Flying Foxes and their immediate allies, seek a different kind of shelter. Their chief natural dormitories consist of hollow trees and the caves and fissures of rocks, to which they often resort in great numbers; but in populous countries they also find an abundance of convenient places of retirement in and about buildings of various kinds. Roofs, especially when covered with tiles, or otherwise provided with apertures through which the space immediately under the roofing is easily accessible, outbuildings of all kinds, church towers and other similar structures, disused chimneys, the spaces

behind weather-boards and shutters which are not often moved, in fact any dark and sheltered places about our buildings, are readily resorted to by many species, although some few retain their taste for unadulterated nature so strongly that no artificial harbor will serve their turn. Thus among the British species the Great Bat or Noctule, a generally distributed though not abundant species throughout the southern and middle counties of England, seems generally to retreat for its diurnal sleep to the holes or cavities in the trunks of trees, and only to visit buildings when there is a scarcity of such accommodation; and the Horseshoe Bats show a decided preference for caverns and deserted quarries; but the great majority appear to be indifferent in the matter, and to resort to any shelter that seems convenient to them. Some, such as the Barbastelle of the southern parts of England, are solitary in their habits, generally retiring alone for their day's rest; others are more sociable, reposing in larger or smaller parties in their dormitories, whether natural or artificial, and sometimes, like the Fruit Bats, collecting in immense numbers.

The common Bats, like the Fruit Bats, sleep in what we should consider an exceedingly uncomfortable position, namely, with their heads downwards, but they cling by the claws of *both* hind feet to the small irregularities of the stone or wood forming the walls and other parts of the structure of their retreat. They frequent the same places year after year, so that, where they are numerous, the ground is often completely covered and discolored with their excrements, which in some cases accumulate in course of time to such an amount

as to have given rise to the notion of carrying it away to be used as guano. The little blood-sucking Vampire Bats already mentioned take up their abode in caverns, and, according to Dr. Hensel, who observed their habits, they discharge their excrements, which are black and pasty, near the entrance of the cave just before starting on their evening flight, and this substance by degrees forms quite a thick layer (one foot or more) on the floor of the cavern. The Doctor says that a large dog which had paid a visit of curiosity to one of these caves came out again looking as if he had got long black boots on.

In the warmer regions of the earth's surface, where their supply of food is constant, the activity of the Bats is not known to have any intermission, but in cold and temperate countries they pass the winter season in a state of torpidity. The period of this hibernation, as it is called, varies somewhat in the different species, but few of them are to be seen flying about, except when the weather is decidedly mild. The commonest of all our British species, the Pipistrelle, has a shorter winter sleep than any of its companions, it usually makes its appearance on the wing by the middle of March, and continues active until quite late in the year; in fact Mr. Gould has recorded the fact of his having shot a specimen of it on a warm sunny day just before Christmas. For the purpose of hibernation the Bats retire to their usual resting-places, but frequently, instead of suspending themselves by their hind feet, as when sleeping, pack themselves away in small parties in holes and crevices, an arrangement which probably furnishes a better protection against the inclemency of the season.

It is probably in the dormitory that the birth of the young bats takes place — at least, so far as we know, the process is affected in a manner which must preclude active exertions on the part of the mother for some little time. The best account of the operation with which we are acquainted is that given fifty years ago by Mr. George Daniell, in a paper read before the Zoölogical Society, in which he described the habits of some Noctules kept by him in captivity. Four out of five died, and the survivor, a female, was observed on 23d June to become very restless, and to continue so for about an hour, although still suspended by the hind limbs in the attitude of repose. "Suddenly," to use Mr. Daniell's words, "she reversed her position, and attached herself by her anterior limbs to a cross wire of the cage, stretching her hind limbs to their utmost extent, curving the tail upwards, and expanding the interfemoral membrane, so as to form a perfect nestlike cavity for the reception of the young . . . which was born on its back, perfectly destitute of hair, and blind. The mother then cleaned it, turning it over in its nest; and afterwards, resuming her usual position, placed the young in the membrane of her wing. She next cleaned herself, and wrapped up the young one so closely as to prevent any observation of the process of suckling. At the time of birth the young was larger than a new-born mouse, and its hind legs and claws were remarkably strong and serviceable, enabling it not only to cling to its dam, but also to the deal sides of the cage. On the 24th the animal took her food in the morning, and appeared very careful of her young, shifting it from side to side to suckle it, and folding it in the membranes of

the tail and wings." Unfortunately, these interesting observations were cut short by the death of the mother, and the young animal, which was with some difficulty removed from the nipple, survived only eight days, during which it was fed with milk from a sponge, and made but little progress, its eyes being still unopened, and its body almost hairless.

There can be no doubt that this process, varied in minor points in accordance with differences of structure, reveals to us what takes place in Bats generally in immediate connection with the birth of the young. From all the observations that have been made it appears certain that the female Bats produce only a single young one at a birth; that this is at first blind, naked, and helpless; and that the female nurses it carefully — a process which must be greatly facilitated by the power of clinging to its parent possessed by the young Bat from the first moment of its appearance in the world. The two nipples possessed by the female are situated upon the breast, sometimes quite at the sides under the arm-pits, a position which renders it particularly easy for the careful mother to tend her offspring, while she is also enabled to carry it about with her in her evening flights, the young creature clinging firmly to its mother's fur, and being quite out of the way of the movements of the wings. This part of the business, of course, could not be exemplified in Mr. Daniell's case, as the female was imprisoned in a cage, but it is a well-known fact in the natural history of these creatures that the mother does carry her young about with her so long as it continues helpless. Apparently, indeed, even after the young animal becomes

capable of flying about, its mother still retains some interest in its well-being — at least, if we may apply generally a case recorded by Dr. Allen in his account of the Bats of North America. It relates to a small species, the Red Bat, very common throughout the United States, a young individual of which having been captured by a lad, "three hours afterwards, in the evening, as he was conveying it to the museum in his hand, while passing near the place where it was caught, the mother made her appearance, and followed the boy for two squares, flying around him, and finally alighted on his breast, such was her anxiety to save her offspring. Both were brought to the museum, the young one firmly adhering to its mother's teat. This faithful creature lived two days in the museum, and then died of injuries received from her captor. The young one being but half grown was still too young to take care of itself, and died shortly after."

This little anecdote seems to set the moral character of the Bat in a very favorable light, at any rate as regards the family affections, and there is no doubt that the females of all the species of the group show considerable fondness for their young. In other respects, perhaps, they do not all shine quite so brilliantly, for, as we have seen, the Fruit Bats squabble very selfishly for the most convenient sleeping places, as indeed do other gregarious species of the order, and some of the former quarrel and fight over their food. As regards amiability of character, however, there is probably considerable difference between different kinds of Bats; at any rate, in confinement, they show much diversity of temper, some of them being sullen, refusing food, and

biting vigorously at their captors or the bars of their prison, while others are easily tamed and soon become familiar. Two of the commonest species, the Pipistrelle, and the Long-eared Bat are among the latter. The Pipistrelle, which appears to be abundant throughout Britain, and indeed in most of the northern temperate regions of the eastern hemisphere, is a small reddish-brown species, measuring little more than one inch and a half in length without the tail, but with a spread of wing of more than eight inches. Its regular food consists chiefly of gnats, midges, and other small flies, in pursuit of which it often frequents the vicinity of water, but it has a curious predilection for raw meat, and in search of this it often makes its way into pantries, where the little thief will be found clinging to a joint of meat, and feeding upon it with avidity. This fondness for meat makes the Pipistrelle very easy to keep in confinement, as it diminishes the necessity of finding it insect food, and the little creature will in time become so tame as to take pieces of meat from its owner's fingers. It is an active and lively little creature, flying, running, and climbing about with great ease; in the latter operation, according to Professor Bell, it makes use of the extreme tip of the tail as if it was a finger.

The Long-eared Bat, so called from the great size of its ears, which are nearly as long as the whole animal exclusive of the tail, has perhaps a wider distribution than the Pipistrelle, but is hardly so abundant in Britain. Its head and body measure nearly two inches long, while its wings spread to about ten inches. This Bat generally sleeps during the day under the roofs of

houses and in church towers, and when sleeping its long ears are carefully stowed away under the folded wings, but the earlet or inner lobe of the ear still projects, so that the creature appears to have a pair of short-pointed ears. The Long-eared Bat flies very late in the evening, and indeed seems to continue its activity throughout the night; its food appears to consist to a great extent of the smaller moths, although other insects are by no means disdained. This species also soon becomes very tame and familiar; it will fly about the room, play with its fellows, and come fearlessly to take its food from the hand. Professor Bell gives an interesting account of one kept by Mr. James Sowerby, which, "when at liberty in the parlor, would fly to the hand of any of the young people who held up a fly toward it, and, pitching on the hand, take the fly without hesitation. If the insect was held between the lips, the Bat would then settle on its young patron's cheek, and take the fly with great gentleness from the mouth; and so far was this familiarity carried, that, when either of the young people made a humming noise with the mouth, in imitation of an insect, the Bat would search about the lips for the promised

Long-eared Bat.

dainty." This habit of taking its food when off the wing, would seem to be natural to the Long-eared Bat under certain circumstances, as Mr. Tomes records his having seen one feeding in this manner upon the myriads of small moths which swarmed about a spindle tree in bloom.

It is unnecessary to say that the creatures which display all this activity and intelligence are well endowed with at least all the senses possessed by the other animals of their class. The organs of smell and hearing are well developed, and in many cases associated with external membranous expansions of great size, as seen in the ears of the Long-eared Bat; and the eyes, though generally of small size except in the Fruit Bats, are bright and efficient, serving the creatures in good stead in the rapid pursuit of their insect-prey, which must be directed principally by sight. The common expression "as blind as a Bat," must be taken to apply to Bats accidentally driven from their retreats in the day-time, when it must be confessed that they fly about in a dazed manner; but at night and in their dark retreats they show no such imbecility of purpose, but find their way with astonishing precision and certainty. In fact, instead of being blind, the Bats must be especially sharp-sighted, if all their evolutions be guided by the sense of sight, for in many cases they habitually resort to the inmost recesses of caverns and other places where, so far as our judgment goes, no light can possibly penetrate. Hence it was long since suspected that some other sense than that of sight must come to their aid when they plunge into such outer darkness as prevails in some places through

which they fly with the greatest freedom, and more than a century ago numerous experiment were made by a distinguished Italian naturalist, the Abbé Spallanzani, in order to discover, if possible, what might be the secret of these curious phenomena.

He set free, in a long passage which was bent at a right angle about the middle of its length, a blinded Bat, which flew through the whole of this passage, turning the corner correctly, without anywhere touching the walls ; while flying, too, it in some mysterious manner detected a hole in the roof at a distance of eighteen inches, and proceeded at once to ensconce itself in this shelter. In another experiment the Abbé took two Bats, one blinded, the other not, and placed them in a space shut off from a garden and roofed in with nets, and with sixteen strings suspended from the top in different parts. Both Bats flew about briskly and avoided the hanging strings equally well, until at length the *blinded* Bat discovered that the meshes of the net were large enough for him to get through, when he at once made his escape, and after flying about for a short time, went off directly to the only roof in the vicinity, under which he disappeared. In short, from these experiments it became perfectly clear that under these circumstances the sense of sight was not of primary importance in guiding the course of the Bat. Similar trials with the organs of smell and hearing showed that they had nothing to do with it, and the only other sense that could be appealed to was the general sense of touch. Baron Cuvier, the great French comparative anatomist, was the first to suggest, from the consideration of the results obtained by the Abbé

Spallanzani and others, especially by M. de Jurine, of Geneva, that the peculiar phenomena in question might be accounted for by the existence, especially in the great membranous expansions of the wings, of a most delicate sensibility; and subsequent investigations of the structure of those organs has tended to confirm this view, so that it is now the one generally accepted. It is found that these great membranes are traversed in all parts by numerous nerves, the delicate terminations of which form little loops, exactly resembling those which occur in our skin in those parts where the sense of touch is most highly developed; and this resemblance is heightened by the fact that the membrane is covered with rows of little points. Even the organs of circulation in the wings are so constructed as to render it almost certain that those organs have a quite exceptional sensibility. Their ramifications are very numerous, and the veins as well as the arteries have contractile walls, rendering the circulation of the blood exceedingly active, the conditions, as Professor St. George Mivart remarks, being almost those of a state of inflammation.

If these membranous expansions have the functions just ascribed to them, we can easily understand that the larger they are the better, and this will explain why the Bats generally exhibit so great a tendency to run out into naked membranes. Thus although the ears, as organs of hearing, have probably nothing to do with guiding the Bat when flying in dark places, we find that in a great number of species the external ears are exceedingly large and delicately membranous, of which indeed we have an example in the British Long-

eared Bat already referred to. In like manner, while the nose, as a nose, may also be left out of consideration, the development of membranous appendages of the part of the face in which the nostrils open is one of the most curious peculiarities of a vast number of Bats, in many of which these singular nose-leaves almost rival the ears in size, while their structure often renders them most grotesque. We have two Bats thus adorned in Britain, namely, the Greater and the Lesser Horseshoe Bats, but most of the leaf-nosed species are inhabitants of warmer regions, and it is there that they run out into the most remarkable eccentricities of structure. In Blainville's Bat, a small species inhabiting South America and the West Indies, these expansions of the skin of the face seem to have reached the utmost possible grotesqueness, but the membranous leaves are larger and the ears much more developed in many species allied to our own Horseshoe Bats, especially such as the Megaderms. We can hardly imagine that these great membranous expansions of the outer ears and the region of the nose can have any other purpose than that of enlarging the surface of highly sensitive skin specially adapted for the perception of external impressions, and it is a remarkable fact, strictly in accordance with this view, that, so far as we know, the Bats so endowed are more decidedly nocturnal in their habits and frequent darker retreats than their less gifted fellows. Thus our Long-eared Bat, as already stated, continues active on the wing throughout the whole night, and the Horseshoe Bats are distinguished as specially affecting dark caves.

HOW SNAKES EAT

(From Snakes.)

By CATHERINE C. HOPLEY.

Hamadryad Snake.

THE Hamadryad's appointed diet is one ring-snake per week; but "Ophi," as we now call him, is occasionally required — and with no sacrifice of his principles either — to eat an extra snake to satisfy the curiosity of some distinguished visitor. Sometimes, too, colubers are plentiful, and two small ones are not too much for his ten or twelve feet of appetite. This splendid serpent has rewarded care by remaining in perfect health, and growing several feet. He was between eight and nine feet long when he came,

and is now not far short of twelve and proportionately larger in circumference. Sometimes during winter, when ring-snakes are scarce, "Ophi" is compelled to fast; for he is not then to be tempted with other food. During the first year of his residence in the Gardens, the supply was good, and he ate no less than eighty-two fellow-creatures before the winter was well over. Towards spring, however, the supply ran short, and only two more remained for him. He had now fasted two entire weeks, and looked hungry and eager. The keeper offered him a guinea-pig, at which he took great offence, raising his hood and hissing angrily for a long while. Eggs he declined, also a lizard and a rat, in great disgust. In India the Ophiophagi are said to feed on lizards and fish occasionally, but *our* Ophiophagus preferred to fast. At last one of the two ring-snakes was produced, and Ophio was to be regaled. It was the 31st of March, 1876, and he had been a denizen of the Gardens just one year. My note-book informs me that it was a lovely, soft spring day, and that Ophio was quite lively. He had rejected frogs on his own account, but in the uncertainty of more ring-snakes arriving, he was now decoyed into eating half a dozen. Holland contrived that the snake destined for his dinner should answer the purpose of a feast, and had allowed it to eat as many frogs as it chose. Like the poor wretch who, doomed to the gallows, is permitted to fare sumptuously the last morning of his life, the ring-snake ate three frogs, by which the Ophiophagus was to derive chief benefit; he, all unconscious of the cause of his victim's unusual plumpness, swallowed him speedily.

Soon after this Ophio doffed his winter coat entire,

and having again fasted for ten days, was at once rewarded by the last remaining ring-snake in a similarly plethoric condition, namely, with three more frogs inside him. Now and then during the winter months the scarcity of ring-snakes has compelled the sacrifice of some far rarer colubers to Ophio's cannibal tastes. And yet each year we hear of hundreds of ring-snakes being ruthlessly killed in country districts, while at great cost and trouble others are purchased or brought from the Continent for the Hamadryad's sustenance. Lord Lilford, one of the Ophidarium's best patrons, sometimes sends presents of game in the shape of ring-snakes to the Hamadyrad.

While watching this snake-eater over his dinner, one is struck with the remarkable tenacity of life exhibited in the victim, or the slow action of the venom if poisoned in the first grasp. The Ophiophagus seizes it anywhere, that is, at whichever part happens to come first, and then, after holding it quietly for a time, works his jaws up to the head in the usual hand-over-hand, or "jaw-after-jaw" fashion, invariably swallowing the snake head first. On one occasion when I watched attentively, Ophio, having seized a ring-snake by the middle, held it doggedly still for one quarter of an hour, while the lesser snake did its very best to work its way out of the jaws, and also to fetter its captor by twirling itself over his head and coiling round his neck. This continued while Ophio, with his head and neck raised, remained motionless, and after the quarter of an hour commenced to work his jaws up towards the head of the ring snake, which, as more and more of its own body was free for action, twirled itself about, and at

length coiled its tail round the bit of branch nailed into the cage.

Persistently, like a sailor making his vessel fast to the windlass, the ring snake lashed as much of himself as was free round the branch a foot off, and so pulled and pulled till he looked in danger of severing himself in two. Meanwhile Ophio, slowly but surely advancing, caused its head and neck to disappear, grasping tightly with his venomous jaws, as if he would say, "We'll see who is master." It was a close tussle, so firmly did the little coluber retain his hold on the "tree"; but as the upper part of him was gradually drawn into those unrelaxing jaws, he by degrees gave way, and by and by was gone.

Not far short of an hour was occupied in this meal, during which the victim showed no signs of being poisoned, nor were his coils round the stump relaxed in the slightest degree, till Ophio reached the tail. The ring snake is not a constrictor, yet he thus tied himself round the tree by the coils of his tail.

One more singular case of tenacity of life must be recorded. A ring-snake had been caught in the usual way, and the usual struggle ensued between captor and captive. Coluber, with its head tightly gripped in the jaws of his enemy, had still all the rest of himself at liberty and in full activity, and after wriggling a violent protest, he coiled what was left of himself so closely round the neck of his persecutor that the latter made little or no progress with his dinner for a time. He seemed to be deliberating how to proceed next, and asking, "What is the meaning of this?" then shook his head, lowered it to the shingle, and tried to rub off

the coils. The only result thus achieved was that the extreme end of Coluber's tail was loosened for a moment, but only to coil afresh around Ophio's jaws, which nevertheless slowly and surely advanced.

For nearly an hour the progress was very slow; but when the ring-snake was nearly all swallowed except a few inches of tail, these became so tight a muzzle that Ophio in turn was the victim. Shaking his head and vainly endeavoring to free his jaws of this muzzle, a minute or two elapsed, during which he seemed to suffer some discomfort, when suddenly his mouth opened widely, and out crawled Natrix, apparently none the worse for this temporary entombment. He had turned round when two or three feet from daylight, and come back to see the world once more. But it so happened that Ophio closed his jaws in time over the few inches of tail which still remained between them. Nor did he once relax his grasp of this, but quickly and patiently began to work his way up to the head and recommence his meal, and this time with better success. An hour and a quarter I watched, nor was any evidence of poison seen, so as to reduce the powers of the bitten snake; for bitten it must have been in those prolonged and forcible grasps.

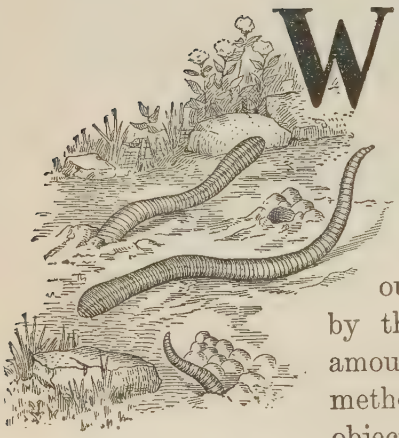
In these conflicts one could but observe a dogged stupidity on the part of the venomous snake, who, had he but brought coils to his aid, might have simplified

matters so easily. The little Heterodons, and even the Lacertines, often assist themselves with coils in managing their prey, though not themselves constrictors; but the venomous ones have not the slightest notion of helping themselves in this way, as if confident that in time their venom would do its work.

WHAT WORMS DO

(From The Formation of Vegetable Mould.)

By CHARLES DARWIN.



WE now come to treat of a curious and important subject, — namely, the amount of earth which is brought up by worms from beneath the surface, and is afterwards spread out more or less completely by the rain and wind. The amount can be judged of by two methods, — by the rate at which objects left on the surface are buried, and more accurately by weighing the quantity brought up within a given time. We will begin with the first method, as it was first followed.

Near Maer Hall in Staffordshire, quick-lime had been spread, about the year 1827, thickly over a field of good pasture-land, which had not since been ploughed. Some square holes were dug in this field in the beginning of October, 1837, and the sections showed a layer

of turf, formed by the matted roots of the grasses, $\frac{1}{2}$ inch in thickness, beneath which, at a depth of $2\frac{1}{2}$ inches (or 3 inches from the surface), a layer of the lime in powder or in small lumps could be distinctly seen running all round the vertical sides of the holes. The soil beneath the layer of lime was either gravelly or of a coarse sandy nature, and differed considerably in appearance from the overlying dark-coloured fine mould. Coal-cinders had been spread over a part of this same field either in the year 1833 or 1834; and when the above holes were dug, that is, after an interval of 3 or 4 years, the cinders formed a line of black spots round the holes, at a depth of 1 inch beneath the surface, parallel to and above the white layer of lime. Over another part of this field cinders had been strewed, only about half a year before, and these either still lay on the surface or were entangled among the roots of the grasses; and I here saw the commencement of the burying process, for worm-castings had been heaped on several of the smaller fragments. After an interval of $4\frac{3}{4}$ years this field was re-examined, and now the two layers of lime and cinders were found almost everywhere at a greater depth than before by nearly 1 inch, we will say by $\frac{3}{4}$ of an inch. Therefore, mould to an average thickness of .22 of an inch had been annually brought up by the worms, and had been spread over the surface of this field.

Coal-cinders had been strewed over another field, at a date which could not be positively ascertained, so thickly that they formed (October, 1837) a layer, 1 inch in thickness at a depth of about 3 inches from the surface. The layer was so continuous that the over-

lying dark vegetable mould was connected with the sub-soil of red clay only by the roots of the grasses; and when these were broken, the mould and the red clay fell apart. In a third field, on which coal-cinders and burnt marl had been strewed several times at unknown dates, holes were dug in 1842; and a layer of cinders could be traced at a depth of $3\frac{1}{2}$ inches, beneath which at a depth of $9\frac{1}{2}$ inches from the surface there was a line of cinders together with burnt marl. On the sides of one hole there were two layers of cinders, at 2 and $3\frac{1}{2}$ inches beneath the surface; and below them at a depth in parts of $9\frac{1}{2}$, and in other parts of $10\frac{1}{2}$ inches there were fragments of burnt marl. In a fourth field two layers of lime, one above the other could be distinctly traced, and beneath them a layer of cinders and burnt marl at a depth of from 10 to 12 inches below the surface.

A piece of waste land was enclosed, drained, ploughed, harrowed, and thickly covered in the year 1822 with burnt marl and cinders. It was sowed with grass seeds, and now supports a tolerably good but coarse pasture. Holes were dug in this field in 1837, or 15 years after its reclamation, and we see in the accompanying diagram (Fig. 1) reduced to half of the natural scale, that the turf was $\frac{1}{2}$ inch thick, beneath which there was a layer of vegetable mould $2\frac{1}{2}$ inches thick. This layer did not contain fragments of any kind; but beneath it there was a layer of mould, $1\frac{1}{2}$ inch in thickness, full of fragments of burnt marl, conspicuous from their red color, one of which near the bottom was an inch in length; and other fragments of coal-cinders together with a few white quartz pebbles.

Beneath this layer and at a depth of $4\frac{1}{2}$ inches from the surface, the original black, peaty, sandy soil with a few quartz pebbles was encountered. Here, therefore, the fragments of burnt marl and cinders had been covered in the course of 15 years by a layer of fine vegetable mould, only $2\frac{1}{2}$ inches in thickness, excluding the turf. Six and a half years subsequently this field was re-examined, and the fragments were now found at from 4 to 5 inches beneath the surface. So that in this interval of $6\frac{1}{2}$ years, about $1\frac{1}{2}$ inch of mould had been added to the superficial layer. I am surprised that a greater quantity had not been brought up during the whole $21\frac{1}{2}$ years, for in the closely underlying black, peaty soil there were many worms. It is, however, probable that formerly, whilst the land remained poor, worms were scanty; and the mould would then have accumulated slowly. The average annual in-

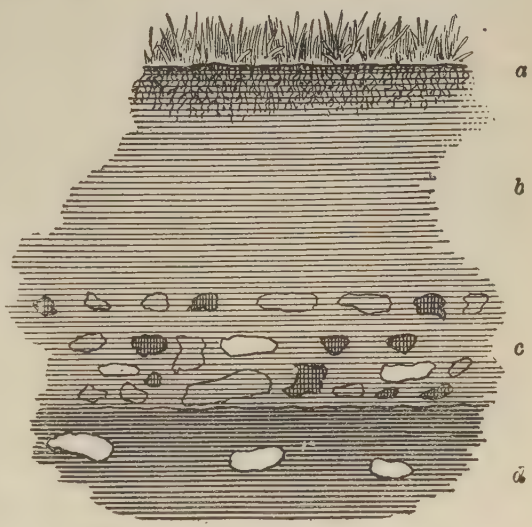


Fig. 1.

Section of the vegetable mould in a field, drained and reclaimed fifteen years previously; *a*, turf; *b*, vegetable mould without any stones; *c*, mould with fragments of burnt marl, coal cinders, and pebbles; *d*, sub-soil of black, peaty sand with quartz pebbles.

crease of thickness for the whole period is .19 of an inch.

Two other cases are worth recording. In the spring of 1835 a field, which had long existed as poor pasture, and was so swampy that it trembled slightly when stamped on, was thickly covered with red sand so that the whole surface appeared at first bright red. When holes were dug in this field after an interval of about $2\frac{1}{2}$ years, the sand formed a layer at a depth of $\frac{3}{4}$ inch beneath the surface. In 1842 (i.e., seven years after the sand had been laid on) fresh holes were dug, and now the red sand formed a distinct layer, 2 inches beneath the surface, or $1\frac{1}{2}$ inch beneath the turf; so that on an average .21 inches of mould had been annually brought to the surface. Immediately beneath the layer of red sand the original sub-stratum of black, sandy peat extended.

A grass field, likewise not far from Maer Hall, had formerly been thickly covered with marl, and was then left for several years as pasture; it was afterwards ploughed. A friend had three trenches dug in this field 28 years after the application of the marl, and a layer of the marl fragments could be traced at a depth, carefuly measured, of 12 inches in some parts, and of 14 inches in other parts. This difference in depth depended on the layer being horizontal, whilst the surface consisted of ridges and furrows from the field having been ploughed. The tenant assured me that it had never been turned up to a greater depth than from 6 to 8 inches; and as the fragments formed an unbroken horizontal layer from 12 to 14 inches beneath the surface, these must have been buried by

the worms whilst the land was in pasture before it was ploughed, for otherwise they would have been indiscriminately scattered by the plough throughout the whole thickness of the soil. Four and a half years afterwards I had three holes dug in this field, in which potatoes had been lately planted, and the layer of marl fragments was now found 13 inches beneath the bottoms of the furrows, and therefore probably 15 inches beneath the general level of the field. It should, however, be observed that the thickness of the blackish, sandy soil, which had been thrown up by the worms above the marl fragments in the course of $32\frac{1}{2}$ years, would have measured less than 15 inches, if the field had always remained as pasture, for the soil would in this case have been much more compact. The fragments of marl almost rested on an undisturbed substratum of white sand with quartz pebbles; and as this would be little attractive to worms, the mould would hereafter be very slowly increased by their action.

We will now give some cases of the action of worms, on land differing widely from the dry, sandy, or the swampy pasture just described. The chalk formation extends all round my house in Kent; and its surface, from having been exposed during an immense period to the dissolving action of rain-water, is extremely irregular, being abruptly festooned and penetrated by many deep, well-like cavities. During the dissolution of the chalk the insoluble matter, including a vast number of unrolled flints of all sizes, has been left on the surface and forms a bed of stiff red clay, full of flints. and generally from 6 to 14 feet in thickness. Over the red clay, wherever the land has long remained as pas-

ture, there is a layer a few inches in thickness of dark-coloured vegetable mould.

A quantity of broken chalk was spread, on December 20, 1842, over a part of a field near my house, which had existed as pasture certainly for 30, probably for twice or thrice as many, years. The chalk was laid on the land for the sake of observing at some future period to what depth it would become buried. At the end of November, 1871, that is, after an interval of twenty-nine years, a trench was dug across this part of the field; and a line of white nodules could be traced on both sides of the trench, at a depth of 7 inches from the surface. The mould, therefore (excluding the turf), had here been thrown up at an average rate of .22 inches per year. Beneath the line of chalk nodules there was in parts hardly any fine earth free of flints, while in other parts there was a layer $2\frac{1}{4}$ inches in thickness. In this latter case the mould was altogether $9\frac{1}{4}$ inches thick; and in one such spot a nodule of chalk and a smooth flint pebble, both of which must have been left at some former time on the surface, were found at this depth. At from 11 to 12 inches beneath the surface, the undisturbed reddish clay, full of flints, extended. The appearance of the above nodules of chalk surprised me much at first, as they closely resembled water-worn pebbles, whereas the freshly-broken fragments had been angular. But on examining the nodules with a lens, they no longer appeared water-worn, for their surfaces were pitted through unequal corrosion, and minute, sharp points, formed of broken fossil shells, projected from them. It was evident that the corners of the original fragments of chalk had been

wholly dissolved, from presenting a large surface to the carbonic acid dissolved in the rain-water and to that generated in soil containing vegetable matter, as well as the humus-acids. The projecting corners would also, relatively to the other parts, have been embraced by a larger number of living rootlets; and these have the power of even attacking marble, as Sachs has shown. Thus, in the course of twenty-nine years, buried angular fragments of chalk had been converted into well-rounded nodules.

Another part of this same field was mossy, and as it was thought that sifted coal-cinders would improve the pasture, a thick layer was spread over this part either in 1842 or 1843, and another layer some years afterwards. In 1871 a trench was here dug, and many cinders lay in a line at a depth of 7 inches beneath the surface, with another line at a depth of $5\frac{1}{2}$ inches parallel to the one beneath. In another part of this field, which had formerly existed as a separate one, and which it was believed had been pasture-land for more than a century, trenches were dug to see how thick the vegetable mould was. By chance the first trench was made at a spot where at some former period, certainly more than forty years before, a large hole had been filled up with coarse, red clay, flints, fragments of chalk, and gravel; and here the fine vegetable mould was only from $4\frac{1}{8}$ to $4\frac{3}{8}$ inches in thickness. In another and undisturbed place, the mould varied much in thickness, namely, from $6\frac{1}{2}$ to $8\frac{1}{2}$ inches; beneath which a few small fragments of brick were found in one place. From these several cases, it would appear that during the last 29 years mould has been heaped on the

surface at an average annual rate of from .2 to .22 of an inch. But in this district when a ploughed field is first laid down in grass, the mould accumulates at a much slower rate. The rate, also, must become very much slower after a bed of mould, several inches in thickness, has been formed; for the worms then live chiefly near the surface, and burrow down to a greater depth so as to bring up fresh earth from below, only during the winter, when the weather is very cold (at which time worms were found in this field at a depth of 26 inches), and during summer, when the weather is very dry.

A field which adjoins the one just described, slopes in one part rather steeply (viz., at from 10° to 15°); this part was last ploughed in 1841, was then harrowed and left to become pasture-land. For several years it was clothed with an extremely scant vegetation, and was so thickly covered with small and large flints (some of them half as large as a child's head) that the field was always called by my sons "the stony field." When they ran down the slope the stones clattered together. I remember doubting whether I should live to see these larger flints covered with vegetable mould and turf. But the smaller stones disappeared before many years had elapsed, as did every one of the larger ones after a time; so that after thirty years (1871) a horse could gallop over the compact turf from one end of the field to the other, and not strike a single stone with his shoes. To anyone who remembered the appearance of the field in 1842, the transformation was wonderful. This was certainly the work of the worms, for though castings were not frequent for several years,

yet some were thrown up month after month, and these gradually increased in numbers as the pasture improved. In the year 1871 a trench was dug on the above slope, and the blades of grass were cut off close to the roots, so that the thickness of the turf and of the vegetable mould could be measured accurately. The turf was rather less than half an inch, and the mould, which did not contain any stones, $2\frac{1}{2}$ inches in thickness. Beneath this lay coarse, clayey earth full of flints, like that in any of the neighboring ploughed fields. This coarse earth easily fell apart from the overlying mould when a split was lifted up. The average rate of accumulation of the mould during the whole thirty years was only .083 inch per year (i.e., nearly one inch in twelve years); but the rate must have been much slower at first, and afterwards considerably quicker.

The transformation in the appearance of this field, which had been effected beneath my eyes, was afterwards rendered the more striking, when I examined in Knole Park a dense forest of lofty beech-trees, beneath which nothing grew. Here the ground was thickly strewed with large, naked stones, and worm-castings were almost wholly absent. Obscure lines and irregularities on the surface indicated that the land had been cultivated some centuries ago. It is probable that a thick wood of young beech-trees sprung up so quickly, that time enough was not allowed for worms to cover up the stone with their castings, before the site became unfitted for their existence. Anyhow, the contrast between the state of the now miscalled "stony field," well stocked with worms, and the present state of the

ground beneath the old beech-trees in Knole Park, where worms appeared to be absent, was striking.

A narrow path running across part of my lawn was paved in 1843 with small flag-stones, set edgeways; but worms threw up many castings, and weeds grew thickly between them. During several years the path was weeded and swept; but ultimately the weeds and worms prevailed, and the gardener ceased to sweep, merely moving off the weeds, as often as the lawn was mowed. The path soon became almost covered up, and after several years no trace of it was left. On removing, in 1877, the thin overlaying layer of turf, the small flag-stones, all in their proper places, were found covered by an inch of fine mould.

Two recently published accounts of substances strewed on the surface of pasture-land, having become buried through the action of worms, may be here noticed. The Rev. H. C. Key had a ditch cut in a field, over which coal-ashes had been spread, as it was believed, 18 years before, and on the clean-cut perpendicular sides of the ditch, at a depth of at least 7 inches, there could be seen, for a length of 60 yards, "a distinct, very even, narrow line of coal-ashes, mixed with small coal, perfectly parallel with the top-sward." This parallelism and the length of the section gives interest to the case. Secondly, Mr. Dancer states that crushed bones had been thickly strewed over a field, and "some years afterwards" these were found "several inches below the surface, at a uniform depth." Worms appear to act in the same manner in New Zealand as in Europe; for Professor J. von Haast has described a section near the coast, consisting of mica-

schist, "covered by 5 or 6 feet of loess, above which about 12 inches of vegetable soil had accumulated." Between the loess and the mould there was a layer from 3 to 6 inches in thickness, consisting of "cores, implements, flakes, and chips, all manufactured from hard basaltic rock." It is, therefore, probable, that the aborigines, at some former period, had left these objects on the surface, and that they had afterwards been slowly covered up by the castings of worms.

Farmers in England are well aware that objects of all kinds, left on the surface of pasture-lands, after a time disappear, or, as they say, work themselves downwards. How powdered lime, cinders, and heavy stones, can work down, and at the same rate, through the matted roots of a grass-covered surface, is a question which has probably never occurred to them.

The sinking of great stones through the action of worms. — When a stone of large size and of irregular shape is left on the surface of the ground, it rests, of course, on the more protuberant parts; but worms soon fill up with their castings all the hollow spaces on the lower side; for, as Hensen remarks, they like the shelter of stones. As soon as the hollows are filled up, the worms eject the earth which they have swallowed beyond the circumference of the stones; and thus the surface of the ground is raised all round the stone. As the burrows excavated directly beneath the stone after a time collapse, the stone sinks a little. Hence it is, that boulders which at some ancient period have rolled down from a rocky mountain or cliff on to a meadow at its base, are always somewhat imbedded in the soil; and, when removed, leave an exact impression of their

lower surfaces in the under-lying fine mould. If, however, a boulder is of such huge dimensions, that the earth beneath is kept dry, such earth will not be inhabited by worms, and the boulder will not sink into the ground.

A lime-kiln formerly stood in a grass-field near Leith Hill Place, in Surrey, and was pulled down 35 years before my visit; all the loose rubbish had been carted away, excepting three large stones of quartzose sandstone, which it was thought might hereafter be of some use. An old workman remembered that they had been left on a bare surface of broken bricks and mortar, close to the foundations of the kiln; but the whole surrounding surface is now covered with turf and mould. The two largest of these stones had never since been moved; nor could this easily have been done, as, when I had them removed, it was the work of two men with levers. One of these stones, and not the largest, was 64 inches long, 17 inches broad, and from 9 to 10 inches in thickness. Its lower surface was somewhat protuberant in the middle; and this part still rested on broken bricks and mortar, showing the truth of the old workman's account. Beneath the brick rubbish the natural sandy soil, full of fragments of sandstone, was found; and this could have yielded very little, if at all, to the weight of the stone, as might have been expected if the sub-soil had been clay. The surface of the field, for a distance of about 9 inches round the stone, gradually sloped up to it, and close to the stone stood in most places about 4 inches above the surrounding ground. The base of the stone was buried from 1 to 2 inches beneath the general

level, and the upper surface projected about 8 inches above this level, or about 4 inches above the sloping border of turf. After the removal of the stone it became evident that one of its pointed ends must at first have stood clear above the ground by some inches, but its upper surface was now on a level with the surrounding turf. When the stone was removed, an exact cast of its lower side, forming a shallow crateriform hollow, was left, the inner surface of which consisted of fine, black mould, excepting where the more protuberant parts rested on the brick-rubbish. A transverse section of this stone, together with its bed, drawn from measurements made after it had been displaced, is here given on a scale of $\frac{1}{2}$ inch to a foot (Fig. 2). The turf-covered border which sloped up to the stone, consisted of fine vegetable mould, in one part 7 inches in thickness. This evidently consisted of worm-castings, several of which had been recently ejected. The whole stone had sunk in the thirty-five years, as far as I could judge, about $1\frac{1}{2}$ inch; and this must have been due to the brick-rubbish beneath the more protuberant parts having been undermined by worms. At this rate, the upper surface of the stone, if it had been left undisturbed, would have sunk to the general level of the field in 247 years; but before

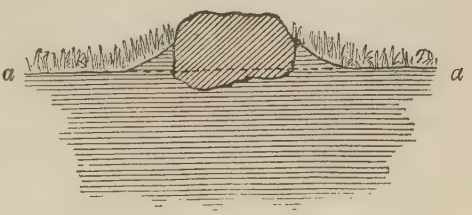


Fig. 2.

Transverse section across a large stone, which had lain on a grass-field for thirty-five years. *aa*, general level of the field. The underlying brick of rubbish has not been represented.

this could have occurred, some earth would have been washed down by heavy rain from the castings on the raised border of turf over the upper surface of the stone.

The second stone was larger than the one just described, viz., 67 inches in length, 39 in breadth, and 15 in thickness. The lower surface was nearly flat, so that the worms must soon have been compelled to eject their castings beyond its circumference. The stone as a whole had sunk about 2 inches into the ground. At this rate it would have required 262 years for its upper surface to have sunk to the general level of the field. The upwardly sloping, turf-covered border round the stone was broader than in the last case, viz., from 14 to 16 inches; and why this should be so, I could see no reason. In most parts this border was not so high as in the last case, viz., from 2 to $2\frac{1}{2}$ inches, but in one place it was as much as $5\frac{1}{2}$. Its average height close to the stone was probably about 3 inches, and it thinned out to nothing. If so, a layer of fine earth, 15 inches in breadth and $1\frac{1}{2}$ inch in average thickness, of sufficient length to surround the whole of the much elongated slab, must have been brought up by the worms in chief part from beneath the stone in the course of 35 years. This amount would be amply sufficient to account for its having sunk about 2 inches into the ground; more especially if we bear in mind that a good deal of the finest earth would have been washed by heavy rain from the castings ejected on the sloping border down to the level of the field. Some fresh castings were seen close to the stone. Nevertheless, on digging a large hole to a depth of 18 inches where the stone had lain, only two worms and a few burrows

were seen, although the soil was damp and seemed favorable for worms. There were some large colonies of ants beneath the stone, and possibly since their establishment the worms had decreased in number.

The third stone was only about half as large as the others; and two strong boys could together have rolled it over. I have no doubt that it had been rolled over at a moderately recent time, for it now lay at some distance from the two other stones at the bottom of a little adjoining slope. It rested also on fine earth, instead of partly on brick-rubbish. In agreement with this conclusion, the raised surrounding border of turf was only 1 inch high in some parts, and 2 inches in other parts. There were no colonies of ants beneath this stone, and on digging a hole where it had lain, several burrows and worms were found.

At Stonehenge, some of the outer Druidical stones are now prostrate, having fallen at a remote but unknown period; and these have become buried to a moderate depth in the ground. They are surrounded by sloping borders of turf, on which recent castings were seen. Close to one of these fallen stones, which was 17 feet long, 6 feet broad, and 28½ inches thick, a hole was dug; and here the vegetable mould was at least 9½ inches in thickness. At this depth a flint was found, and a little higher up on one side of the hole a fragment of glass. The base of the stone lay about 9½ inches beneath the level of the surrounding ground, and its upper surface 19 inches above the ground.

A hole was also dug close to a second huge stone, which in falling had broken into two pieces; and this

must have happened long ago, judging from the weathered aspect of the fractured ends. The base was buried to a depth of 10 inches, as was ascertained by driving an iron skewer horizontally into the ground beneath it. The vegetable mould forming the turf-covered sloping border round the stone, on which many castings had recently been ejected, was 10 inches in thickness; and most of this mould must have been brought up by worms from beneath its base. At a distance of 8 yards from the stone, the mould was only $5\frac{1}{2}$ inches in thickness (with a piece of tobacco pipe at a depth of 4 inches), and this rested on broken flint and chalk which could not have easily yielded to the pressure or weight of the stone.

A straight rod was fixed horizontally (by the aid of a spirit-level) across a third fallen stone, which was 7 feet 9 inches long; and the contour of the projecting parts and of the adjoining ground, which was not quite level, was thus ascertained, as shown in the accompanying diagram (Fig. 3) on a scale of $\frac{1}{2}$ inch to a foot. The turf-covered border sloped up to the stone on one side to a height of 4 inches, and on the opposite side to only $2\frac{1}{2}$ inches above the general level. A hole was dug on the eastern side, and the base of the stone was here found to lie at a depth of 4 inches beneath the

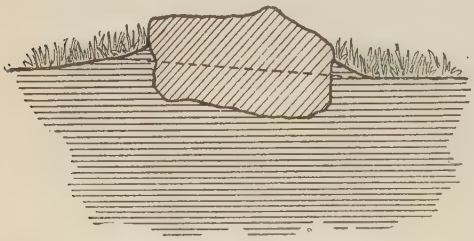


Fig. 3.

Section through one of the fallen Druidical stones at Stonehenge, showing how much it had sunk into the ground.

general level of the ground, and of 8 inches beneath the top of the sloping turf-covered border.

Sufficient evidence has now been given showing that small objects left on the surface of the land where worms abound soon get buried, and that large stones sink slowly downwards through the same means. Every step of the process could be followed, from the accidental deposition of a single casting on a small object lying loose on the surface, to its being entangled amidst the matted roots of the turf, and lastly to its being embedded in the mould at various depths beneath the surface. When the same field was re-examined after the interval of a few years, such objects were found at a greater depth than before. The straightness and regularity of the lines formed by the embedded objects, and their parallelism with the surface of the land, are the most striking features of the case; for this parallelism shows how equably the worms must have worked; the result being, partly the effect of the washing down of the fresh castings by rain. The specific gravity of the objects does not affect their rate of sinking, as could be seen by porous cinders, burnt marl, chalk and quartz pebbles, having all sunk to the same depth within the same time. Considering the nature of the sub-stratum, which at Leith Hill Place was sandy soil including many bits of rock, and at Stonehenge, chalk-rubble with broken flints; considering, also, the presence of the turf-covered sloping border of mould round the great fragments of stone at both these places, their sinking does not appear to have been sensibly aided by their weight, though this was considerable.

On the number of worms which live within a given

space. — We will now show, first, what a vast number of worms live unseen by us beneath our feet, and, secondly, the actual weight of the earth which they bring up to the surface within a given space and within a given time. Hensen, who has published so full and interesting an account of the habits of worms, calculates, from the number which he found in a measured space, that there must exist 133,000 living worms in a hectare of land, or 53,767 in an acre. This latter number of worms would weigh 356 pounds, taking Hensen's standard of the weight of a single worm, namely, one gram. It should, however, be noted that this calculation is founded on the numbers found in a garden, and Hensen believes that worms are here twice as numerous as in corn-fields. The above result, astonishing though it be, seems to me credible, judging from the number of worms which I have sometimes seen, and from the number daily destroyed by birds without the species being exterminated. Some barrels of bad ale were left on Mr. Miller's land, in the hope of making vinegar, but the vinegar proved bad, and the barrels were upset. It should be premised that acetic acid is so deadly a poison to worms that Perrier found that a glass rod dipped into this acid and then into a considerable body of water in which worms were immersed, invariably killed them quickly. On the morning after the barrels had been upset, "the heaps of worms which lay dead on the ground were so amazing, that if Mr. Miller had not seen them, he could not have thought it possible for such numbers to have existed in the space." As further evidence of the large number of worms which live in the ground Hensen states that he found in a

garden 64 open burrows in a space of $14\frac{1}{2}$ square feet, that is, 9 in 2 square feet. But the burrows are sometimes much more numerous, for when digging in a grass-field near Maer Hall, I found a cake of dry earth, as large as my two open hands, which was penetrated by seven burrows, as large as goose-quills.

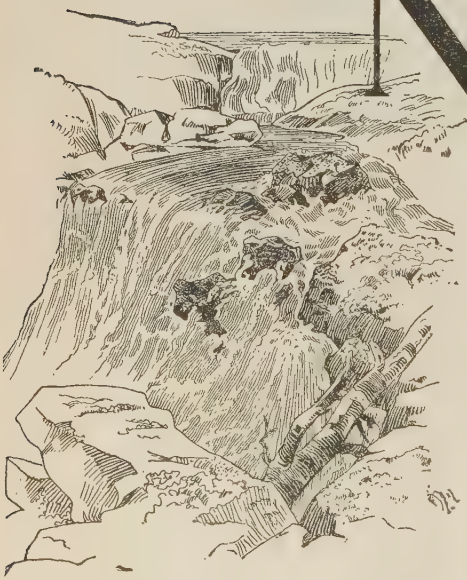
TWO FOPS AMONG THE FISHES

(From Gleanings From Nature.)[1]

By W. S. BLATCHLEY.

I.—THE RAINBOW DARTER.

"Little fishy in the brook."



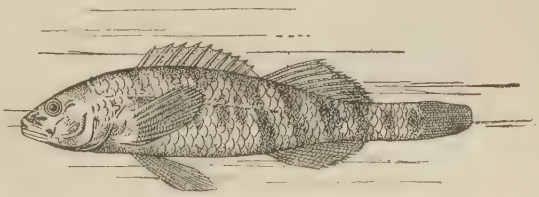
NOT the one "daddy caught with a hook," but another, too small for the hook, too small for the frying-pan, too small for aught else but beauty, and gracefulness of form; and yet not the young of a larger fish, but full grown of himself. In every brook in the State he may be found, yea, even in the rill, no more than a foot in width, which leads away from the old spring-house on the hillside. You will not find him swimming about like the minnows in the still, deep

[1] Copyright by W. S. Blatchley, 1899.

water of the stream, but where the clear, cold water is rushing rapidly over the stones of a ripple he makes his home. There he rests quietly on the bottom, waiting patiently for his food, the larvæ or young of gnats, mosquitoes, and other such insects, to float by.

If you attempt to catch him, or your shadow suddenly frightens him, with a sweep of his broad pectoral or breast fins, he moves quicker than a flash a few feet farther up the stream, and then as suddenly comes to a stop, and resumes his quiet, "thoughtful" attitude. If you persist in your attempt to capture him, he will dart under a small stone or submerged leaf, where, like the foolish ostrich which when pursued hides her head under her wing, no longer seeing you, he thinks himself secure.

On account of the shape of his body, as well as on account of his rapid movements, he has received the surname "darter." Belonging to the group which bears this surname, there are, in the eastern half of the United States, about forty-seven species or kinds, the largest of which, when full grown, measures only about six inches in length, while the smallest species never reaches a length of more than an inch and a half. They all have the same habits, and at least twenty-nine kinds of them are found in Indiana; but the one of which I am writing is much the more common. He is from two



Rainbow Darter.

to two and a half inches in length, and, like the other members of his family, has two fins on his back; "dorsal" fins they are called by naturalists, the front one of which contains ten short spines. During eight months of the year, the males and females dress alike in a suit of brownish olive which is striped on the sides with ten or twelve narrow, black cross-bars, and more or less blotched on the back with darker spots. But on the first warm days of spring, when the breezes blow up from the gulf, awakening the gypsy in our blood, the little male fish feels, too, their influence, and in him there arises an irresistible desire to "a-courting go." Like most other beings of his sex, he thinks his every-day suit too plain for the important business before him. It will, in his opinion, ne'er catch the eye of his lady love. So he dons one of gaudy colors and from it takes his name, — the rainbow darter, — for in it he is best known, as it not only attracts the attention of his chosen one, but often also that of the wandering naturalist who happens along the stream.

The blackish bars of other seasons are changed to indigo blue, while the space between them assumes a hue of the brightest orange. The fins are broadly edged with blue and have the bases orange, or orange and scarlet, while the cheeks assume the blue and the breast becomes an orange. Clad in this suit he ventures forth on his mission, and if successful, as he almost always is, the two construct a nest of tiny stones in which the eggs of the mother-fish are laid and watched over with jealous care by both parents until in time there issue forth sons destined some day to wear a coat of many colors, and "darters" to be

attracted by those coats, as was their mother by the one their father wore.

Although so abundant and so brilliant in the spring-time, the rainbow darter is known to few but naturalists. The fishes in which the average country boy is interested are the larger ones — such as the goggle-eye, the sucker, chub, and sunfish — those which, when caught, will fill up the string and tickle the palate.

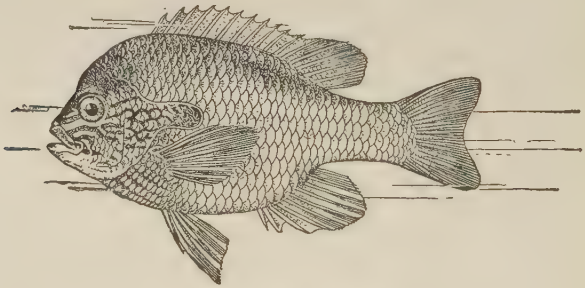
But there are, let us hope, among our farmers' sons and daughters, some who are learning to take an interest in the objects of nature which are beautiful, as well as in those which are useful. To them I will say, if you wish to see something really pretty, make a seine from an old coffee sack or a piece of mosquito netting, and any day in spring drag two or three ripples of the branch which flows through the wood's pasture, and ten chances to one you will get some "rainbows." By placing them in a fruit jar three-fourths full of clear, cold water, and renewing the water every few hours, they can be kept for several days; but they cannot bear the confinement long, accustomed as they are to the free running stream from which they were taken.

By taking the rainbow as the type of the darter and studying closely its habits, both in captivity and in the streams, much can be learned about a group which, in the words of Dr. S. A. Forbes, "are the mountaineers among fishes. Forced from the populous and fertile valleys of the river beds and lake bottoms, they have taken refuge from their enemies in the rocky highlands where the free waters play in ceaseless torrents, and there they have wrested from stubborn nature a meagre living. Although diminished in size by their continual

struggle with the elements, they have developed an activity and hardihood, a vigor of life and a glow of high color almost unknown among the easier livers of the lower lands."

II. — THE LONG-EARED SUNFISH.

Among the most brightly colored of all the fresh-water members of the finny tribe is the long-eared sun-fish. When full grown its length is about eight inches and the breadth one-half as much. The color is then a brilliant blue and orange, the former predominating



Long-eared Sunfish.

above; the orange on the sides in spots, the blue in wavy, vertical streaks. The cheeks are orange with bright blue stripes; the fins with the membranes orange, and the rays blue. Extending back from the hind margin of each cheek is a conspicuous blackish membrane termed an "ear-flap," which in this species is longer than in any other of the sun-fish family, whence the specific name, *megalotis*, from two Greek words meaning "great" and "ear."

Within the placid pools of the brooks and larger streams of the State this sunfish has its favorite haunts. Mid-summer is the time when its habits can

be best observed. On a recent August morn I sat for an hour or longer on the banks of a stream, which flows through a wooded blue-grass pasture, and watched the denizens of its waters. A peaceful calm existed, the water being without a ripple and with scarce the semblance of a flow — the air without the shadow of a breeze. Dragon flies lazily winged their way across the pool, now resting daintily upon a blade of sedge or swamp grass, now dipping the tips of their abdomens beneath the surface of the water while depositing their eggs. The only sounds of nature were the buzz of a bumble-bee feeding among the flowers of the *Brunella* at my side, and an occasional drawl of a dog-day locust from the branches of the sycamore which threw a grateful shade about me.

The sunfish "hung motionless" in the water, their heads towards me, holding their position only by a slow flapping of their dorsal and pectoral fins. Their nesting time over, their season's labor ended, it was with them, as with many other beings, a time of languor.

These long-eared fishes are the lords and ladies of the respective pools wherein they abide. When they move other smaller fry clear the way. If a worm or gnat, falling upon the surface, tempts them, it is theirs. A leaf falls near them and is seemingly unnoticed — a fly, and how quickly their dormant energy is put into motion. With a dart and a gulp the insect is swallowed, and a new stage of waiting expectancy is ushered in.

How admirably fitted their form for cleaving the water! They often seem to glide rather than propel themselves through its depths. Again, how swiftly

the caudal fin moves when with straight unerring motion they dart upon their prey. At times one turns his body sideways, and, with a slow, upward-gliding motion, moves toward some object on the surface which is doubtfully "good to eat." He even takes it into his mouth and then, not having faith in his power to properly digest it, ejects it with force, and turning quickly darts back to the friendly shadow of a boulder beneath whose sides he has, in time of threatened danger, a safe retreat.

I throw a grasshopper into the pool. Like a flash six of the sunfish are after it. One reaches it a tenth of a second in advance of the others, and with a lightning-like gulp, which disturbs the serenity of the surface of the pool, swallows the kicking prey. The energy of the sun's heat and light, stored in grass, transmitted to move muscles in gigantic leaps, will, in a short time, wag a caudal fin and propel the owner through these watery depths.

Years are thus doubtless spent by these long-eared sunfish in a dreamy sort of existence, their energies quickened by the vernal season and growing duller on the approach of winter. Excepting the times when they are tempted by a wriggling worm on some boy's hook, theirs is a life exempt from danger. A king-fisher glancing down from his perch on the bent sycamore limb may, at times, discern them and lessen their ranks; but, methinks, the chub minnows, with fewer spines in their dorsal fins, are more agreeable to the king-fisher's palate. With all the tints of the rainbow gleaming from their sides they move to and fro, the brilliant rulers of these quiet pools.

The king or monarch of those noted was most gorgeously arrayed. In addition to the hues above described, a streak of emerald bordered his dorsal and caudal fins and was bent around the edge of his upper lip — a green mustache, as it were. By tolling them with occasional bits of food I drew him and his retinue close into shore. There, for some time they rested, watching eagerly for additional morsels. As I was leaving I plucked from my sleeve an ant and threw it towards them. A dart, a gurgle, a gulp — the leader had leaped half his length from the water, and the ant was forever gone. The ripples receded and finally disappeared, and the last scene in this tragedy of nature was at an end.

SEA-SLUGS AND CUTTLE-FISH

(From A Journal of Researches.)

By CHARLES DARWIN.

Cuttle-Fish.

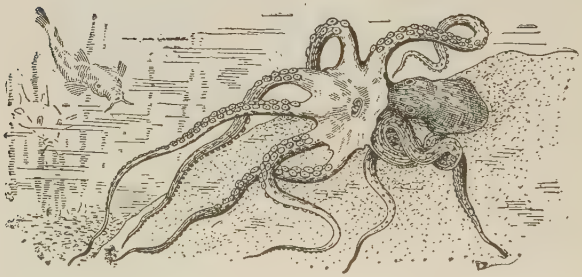
I WAS much interested, on several occasions, by watching the habits of an Octopus, or cuttle-fish. Although common in the pools of water left by the retiring tide, these animals were not easily caught. By means of their long arms and suckers, they could drag their bodies into very narrow crevices; and when thus fixed, it required great force to remove them. At other times they darted, tail first, with the rapidity of an arrow, from one side of the pool to the other, at the same instant discoloring the water with a dark chestnut-brown ink. These animals also escape detection by a very extraordinary, chameleon-like power of changing their color. They appear to vary their tints according to the nature of the ground over which they pass: when in deep water, their general shade was brownish-purple, but when placed on the land, or in

shallow water, this dark tint changed into one of a yellowish green. The color, examined more carefully, was a French gray, with numerous minute spots of bright yellow: the former of these varied in intensity; the latter entirely disappeared and appeared again by turns. These changes were effected in such a manner, that clouds, varying in tint between a hyacinth red and a chestnut brown, were continually passing over the body. Any part, being subjected to a slight shock of galvanism, became almost black: a similar effect, but in a less degree, was produced by scratching the skin with a needle. These clouds, or blushes as they may be called, are said to be produced by the alternate contraction and expansion of minute vescicles containing variously colored fluids.

This cuttle-fish displayed its chameleon-like power both during the act of swimming and whilst remaining stationary at the bottom. I was much amused by the various arts to escape detection used by one individual, which seemed fully aware that I was watching it. Remaining for a time motionless, it would then stealthily advance an inch or two, like a cat after a mouse; sometimes changing its color: it thus proceeded, till having gained a deeper part, it darted away, leaving a dusky train of ink to hide the hole into which it had crawled.

While looking for marine animals, with my head about two feet above the rocky shore, I was more than once saluted by a jet of water, accompanied by a slight grating noise. At first I could not think what it was, but afterwards I found out that it was this cuttle-fish, which, though concealed in a hole, thus often led me to its discovery. That it possesses the power of ejecting

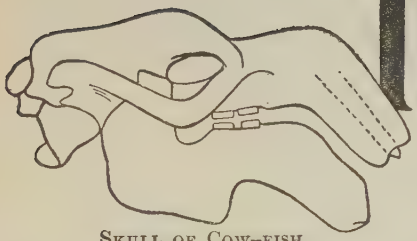
water there is no doubt, and it appeared to me that it could certainly take good aim by directing the tube or siphon on the upper side of its body. From the difficulty which these animals have in carrying their heads, they cannot crawl with ease when placed on the ground. I observed that one which I kept in the cabin was slightly phosphorescent in the dark.



THE COW-FISH

(From Travels on the Amazon.)

By SIR ALFRED RUSSELL WALLACE.



Skull of Cow-fish.

IT was a female, about six feet long, and nearly five in circumference in the thickest part. The body is perfectly smooth, and without any projections or inequalities, changing into a horizontal semicircular flat tail, with no appearance whatever of hind limbs. There is no distinct neck; the head is not very large, and is terminated by a large mouth and fleshy lips, somewhat resembling those of a cow. There are stiff bristles on the lips, and a few distantly scattered hairs over the body. Behind the head are two powerful oval fins, and just beneath them are the breasts, from which, on pressure being applied, flows a stream of beautiful white milk. The ears are minute holes, and the eyes very small. The color is a dusky lead, with some large pinkish-white marbled blotches on the belly. The skin is about an inch thick on the back, and a quarter of an inch on the belly. Beneath the skin is a layer of fat of a greater or less thickness, generally about an inch, which is boiled down to make an oil used for light and for cooking. The in-

testines are very voluminous, the heart about the size of a sheep's, and the lungs about two feet long, and six or seven inches wide, very cellular and spongy, and can be blown out like a bladder. The skull is large and solid, with no front teeth; the vertebræ extend to the very tip of the tail, but show no rudiments of posterior limbs; the fore limbs, on the contrary, are very highly developed, the bones exactly corresponding to those of the human arm, having even the five fingers, with every joint distinct, yet enclosed in a stiff inflexible skin, where not a joint can have any motion.

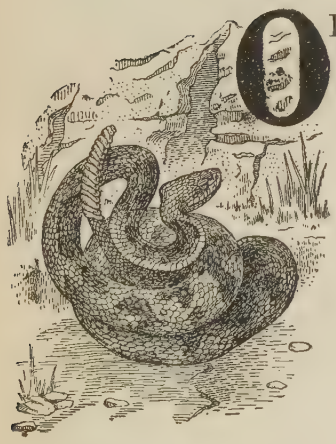
The cow-fish feeds on grass at the borders of the rivers and lakes, and swims quickly with the tail and paddles; and though the external organs of sight and hearing are so imperfect, these senses are said by the hunters to be remarkably acute, and to render necessary all their caution and skill to capture the animals. They bring forth one, or rarely two, young ones, which they clasp in their arms or paddles while giving suck. They are harpooned or caught in a strong net, at the narrow entrance of a lake or stream. Each yields from five to twenty-five gallons of oil. The flesh is very good, being something between beef and pork, and this one furnished us with several meals, and was an agreeable change from our fish diet.

THE COW FISH.

OLD RATTLER AND THE KING SNAKE[1]

By DAVID STARR JORDAN.
President of Leland Stanford, Junior, University.

"I only know thee humble, bold,
Haughty, with miseries untold,
And the old curse that left thee cold,
And drove thee ever to the sun
On blistering rocks . . .
Thou whose fame
Searchèst the grass with tongue of flame,
Making all creatures seem thy game,
When the whole woods before thee run,
Asked but — when all is said and done —
To lie, untrodden, in the sun! — Bret Harte.



OLD RATTLER was a snake, of course, and he lives in the King's River Cañon, high up and down deep in the mountains of California.

He had a hole behind and below a large, flat granite rock, not far from the river, and he called it his home; for in it he slept all night and all winter, but when the sun came back in the spring and took the frost out of the air and the rocks, then he crawled out to lie until he got warm. The stream was clear and swift in

[1] From *The Popular Science Monthly* by permission.

the cañon, the waterfalls sang in the side gulch of Roaring River, the wind rustled in the long needles of the yellow pines, and the birds called to their mates in the branches. But Old Rattler did not care for such things. He was just a snake, you know, and his neighbors did not think him a good snake at that, for he was surly and silent, and his big, three-cornered, "coffin-shaped" head, set on a slim, flat neck, was very ugly to see. But when he opened his mouth he was uglier still, for in his upper jaw he had two long fangs, and each one was filled with deadly poison. His vicious old head was covered with gray and wrinkled scales, and his black, beadlike eyes snapped when he opened his mouth to find out whether his fangs were both in working order.

Old Rattler was pretty stiff when he first came from his hole on the morning of this story. He had lain all night coiled up like a rope among the rocks, and his tail felt very cold. But the glad sun warmed the cockles of his heart, and in an hour or two he became limber, and this made him happy in his snaky fashion. But, being warm, he began to be hungry, for it had been a whole month since he had eaten anything. When the first new moon of August came, his skin loosened everywhere and slipped down over his eyes like a veil, so that he could see nothing about him, and could not hunt for frogs by the river, nor for chipmunks among the trees. But with the new moon of September all this was over. The rusty brown old coat was changed for a new suit of gray and black, and the diamond-shaped checkers all over it were clean and shiny as a set of new clothes ought to be.

There was a little striped chipmunk running up and down the sugar-pine tree over his head, pursing his little mouth and throwing himself into pretty attitudes, as though he were the centre of an admiring audience, and Old Rattler kept a steady eye on him. But he was in no hurry about it all. He must first get the kinks out of his neck, and the cold cramps from his tail. There was an old curse on his family, so the other beasts had heard, that kept him always cold, and his tail was the coldest part of all. So he shook it a little, just to show that it was growing limber, and the bone clappers on the end rustled with a sharp, angry noise. Fifteen rattles he had in all — fifteen and a button — and to have so many showed that he was no common member of his hated family. Then he shook his tail again, and more sharply. This was to show all the world that he, Old Rattler, was wide awake, and whoever stepped on him would better look out. Then all the big beasts and little beasts who heard the noise fled away just as fast as ever they could; and to run away was the best thing they could do, for when Old Rattler struck one of them with his fangs all was over with him. So there were many in the cañon, beasts and birds and snakes too, who hated Old Rattler, but only a few dared face him. And one of these was Glittershield, whom men call the King of Snakes, and in a minute I shall tell you why.

And when Old Rattler was doing all that I have said, the King Snake lay low on a bed of pine needles, behind a bunch of fern, and watched him with keen, sharp eye. The angry buzz of Rattler's tail, which scared the chipmunks and the bullfrogs and all the rest

of the beast folk, was music for Glittershield. He was a snake, too, and snakes understand some things better than any of the rest of us.

Glittershield was slim and wiry in his body, as long as Old Rattler himself, but not so large around. His coat was smooth and glossy, not rough and wrinkly like Old Rattler's, and his upraised head was small and pretty — for a snake. He was the best dressed of all his kind, and he looked his finest as he faced Old Rattler. His head was shiny black, his throat and neck as white as milk while all down his body to the end of his tail he was painted with rings, first white, then black, then crimson, and every ring was bright as if it had just been freshly polished that very day.

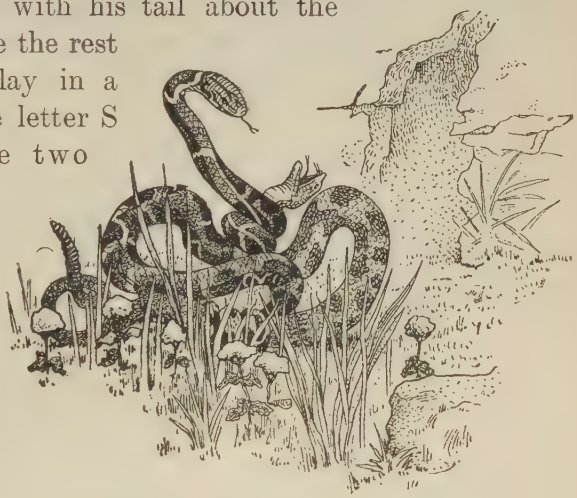
So the King Snake passed the sheltering fern and came right up to Old Rattler. Rattler opened his sleepy eyes, threw himself on guard with a snap and a buzz, and shook his bony clappers savagely. But the King of Snakes was not afraid. Every snake has a weak spot somewhere, and that is the place to strike him. If he hadn't a weak spot no one else could live about him, and then, perhaps he would starve to death at last. If he had not some strong points, where no one could harm him, he couldn't live himself.

As the black crest rose, Old Rattler's tail grew cold, his head dropped, his mouth closed, he straightened out his coil, and staggered helplessly toward his hole.

This was the chance for Glittershield. With a dash so swift that all the rings on his body — red, white, and black — melted into one purple flash, he seized Old Rattler by his throat. He carried no weapons, to be sure. He had neither fangs nor venom. He won his

victories by force and dash, not by mean advantage. He was quick and strong, and his little hooked teeth held like the claws of a hawk. Old Rattler closed his mouth because he couldn't help it, and the fangs he could not use were folded back against the roof of his jaw.

The King Snake leaped forward, wound his body in a "love-knot" around Old Rattler's neck, took a "half-hitch" with his tail about the stomach, while the rest of his body lay in a curve like the letter S between the two knots. Then all he had to do was to stiffen up his muscles, and Old Rattler's backbone was snapped off at the neck.

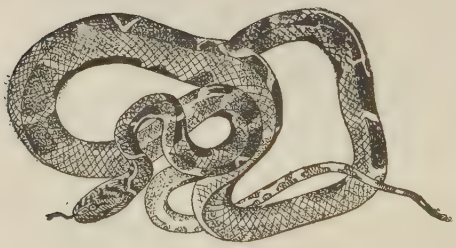


"He Seized Old Rattler by His Throat."

All that remained to Glittershield was to swallow his enemy. First he rubbed his lips all over the body, from the head to the tail, till it was slippery with slime. Then he opened his mouth very wide, with a huge snaky yawn, and face to face he began on Old Rattler. The ugly head was hard to manage, but, after much training, he clasped his jaws around it, and the venom trickled down his throat like some fiery sauce. Slowly head and neck and body disap-

peared, and the tail wriggled desparingly, for the tail of the snake folk can not die till sundown, and when it went at last the fifteen rattles and the button were keeping up an angry buzz. And all night long the King of Snakes, twice as big as he ought to be, lay gorged and motionless upon Old Rattler's rock.

And in the morning the little chipmunk ran out on a limb above him, pursed up his lips, and made all kinds of faces, as much as to say, "I did all this, and the whole world was watching while I did it."



King Snake.

THE STORY OF A STRANGE LAND

(From Science Sketches.)[1]

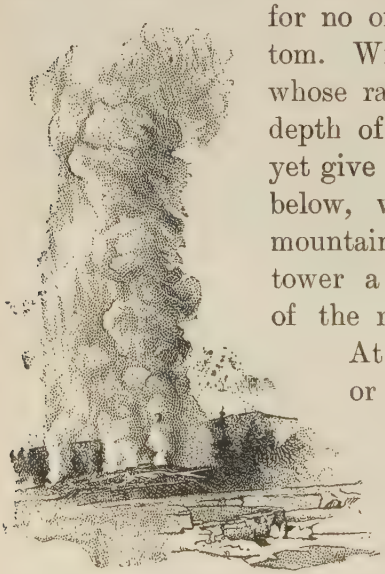
By DAVID STARR JORDAN.
President of Leland Stanford, Junior, University.

"In one strange land,
And a long way from home,
I heard a mighty rumbling, and I couldn't tell where."
—Negro Melody.

IT happened a long time ago, it may be fifty thousand years in round numbers, or it may have been twice as many, that a strange thing thing took place in the heart of the Great Mountains. It was in the middle of the Pliocene epoch, a long, dull time that seemed as if it would never come to an end. There was then on the east side of the Great Divide a deep, rocky basin surrounded by high walls of granite gashed to the base by the wash of many streams. In this basin, we know not how — for the records all are burned or

[1] Copyright, 1896, by A. C. Mclurg & Co.

buried — the crust of the earth was broken, and a great outflow of melted larva surged up from below. This was no ordinary eruption, but a mighty outbreak of the earth's imprisoned forces. The steady stream of lava filled the whole mountain basin and ran out over its sides, covering the country all around so deeply that it has never been seen since. More than four thousand square miles of land lay buried under melted rock. No one can tell how deep the lava is, for no one has ever seen the bottom. Within its bed are deep clefts whose ragged walls descend to the depth of twelve hundred feet, and yet give no glimpse of the granite below, while at their side are mountains of lava whose crags tower a mile above the bottom of the ravines.



"It Would Hiss and Boil High in the Air."

At last, after many years or centuries — time does not count for much in these Tertiary days — the flow of melted lava ceased. Its surface cooled, leaving a high, uneven plain, black and desolate, a hard, cold crust over a fiery and smoldering interior. About the crater lay great ropes and rolls of the slowly hardening lava, looking like knots and tangles of gigantic reptiles of some horrible extinct sort. There was neither grass nor trees, nor life of any sort. Nothing could grow in the coarse, black stone. The rivers

and brooks had long since vanished in steam, the fishes were all dead, and the birds had flown away. The whole region wore the aspect of the desolation of death.

But to let land go to waste is no part of Mother Nature's plan. So even this far-off corner of her domain was made ready for settlement. In the winter she sifted snow on the cold black plain, and in the summer the snow melted into a multitude of brooks and springs. The brooks gradually wore paths and furrows down the large bed, and the sands which they washed from one place they piled up in another. The winds blew the seeds of grasses about, and willows and aspens crept up the mountain-sides. Then came the squirrels, scattering the nuts of the pine. Other seeds came too, in other ways, till at last the barren hillside was no longer barren.

The brooks ran over the surface of the crust undisturbed by the fires within, and were clear and cold as mountain brooks should be; but the rain and melted snow will never all remain on the surface. Some of it falls into cracks or joints or porous places in the rock, and from this come underground streams or springs. But in this region a stream could not run long underground without coming in contact with the old still-burning fires. When a crust is formed over the lava, it cools very slowly. When the crust is a rod or two deep, the lava within is almost as well protected as if it were at the center of the earth.

Whenever the water came down into the fire, the hot rocks would be furious with indignation, and tearing the water to atoms they would throw it back to the surface as steam. Then the explosive force of the steam

would in turn tear up the rocks, making still larger the hole through which the water came. When the rocks were very hot, a little water upon them would make a terrible commotion like the shock of an earthquake. When much water came down, it would hiss and boil high in the air, as it tried to break the cushion of steam which came between it and the lava.

And all this went on in hundreds of places and maybe for thousands of years. The hot rocks glowed and sweltered in the ground, and the cold snow-water crept after them closer and closer, while more and more vigorously the rocks resented the intrusion. Sometimes the

Mouth of Geyser.

water would go down in a mass through a cleft, when it would be hurled bodily the very way it came. At other times the water came down little by little, insinuating itself into many places at once. Then the hot rocks threw it back in many little honeycomb channels, and by the spreading of these channels the rocks were at last crumbled to pieces. The hard black lava on the glass-like obsidian were changed to white kaolin as soft and powdery as chalk. And as the water fought its way, gaining a little every year, steadily working between the joints in the enemy's armor and as surely being thrown back with violence if it penetrated too far, the animals and the plants followed in

the wake of the water, and took possession of the territory as fast as it was won.

At last the Pliocene times were over, for all times come to an end. The one sure thing on the earth is the certainty of change. With the change of time came on the earth's great winter. The snow-drifts on the lava were piled up mountain-high. Snow is but ice gathered in little fragments which will grow solid under pressure. As the snow accumulated it began to move, forming great rivers of ice which ran down the courses of the stream. And as these slowly moving, gigantic ice-rivers tore away huge blocks of lava and pushed them down the mountain-sides, where the rocks had been softened by the action of steam, the ice wore out deep valleys, and everything that it touched was smoothed and polished. The winter of the great Ice age lasted a very long time, many thousands of years; but, long as it was and long ago, it came at last to an end — not to a full stop, of course, for even now, some of its snow still lingers on the highest peaks that surround the lava-beds.

"Cutting Deep Gorges or Cañons."

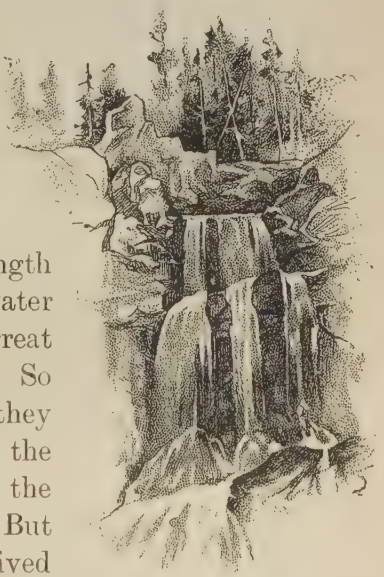
Then the winters grew shorter and the summers

longer. The south winds blew and the ice melted away, first from the plain and then from the mountains. The water ran down the sides of the lava-bed, cutting deep gorges or cañons, so deep that the sun can hardly see the bottom. And into the joints and clefts of the rocks more and more water went, to be hurled back with greater and greater violence, for all the waters of all the snow cannot put out a mile deep of fire.

In the old depressions where the ice had chiselled away the softer rocks, there were formed lakes of the standing water, and one of these was more than thirty miles long, winding in and out among the mountain-ridges. In the lake bottom the water soaked through down to the hot lava below, from which it was thrown boiling back to the surface again, fountains of scalding water in the icy lake.

The cold Ice age had killed all the plants in the region; and it had driven off the animals that could be driven, and had then buried the rest. But when the snow was gone the creatures all came back again. Grass and meadow-flowers of a hundred kinds came up from the valleys below. The willow and the aspen took their place again by the brook-side, and the red fir and the mountain pine covered the hills with their sombre green. The birds came back. The wild goose swam and screamed, and the winter wren caroled his bright song — loudest when there seemed least cause for rejoicing. The beaver cut his timber and patiently worked at his dams. The thriftless porcupine destroyed a tree for every morning meal. The gray jay, the "camp robber," followed the Indians about in hope that

some forgotten piece of meat or of boiled root might fall to his share; while the buffalo, the bear, and the elk each carried on his affairs in his own way, as did a host of lesser animals, all of whom rejoiced when this snow-bound region was at last opened for settlement. Time went on. The water and the fire were every day in mortal struggle, and always when the water was thrown back repulsed, it renewed the contest as vigorously as before. The fire retreated, leaving great stretches of land to its enemy, that it might concentrate its strength where its strength was greatest. And the water steadily gained, for the great ocean ever lay behind it. So for century after century they wrestled with each other, the water, the fire, the snow, the animals and the plants. But the fishes who had once lived in the mountain torrents were no longer there. They had been boiled and frozen, and in one way or another destroyed or driven away. Now they could not get back. Every stream had its cañon, and in each cañon was a waterfall so high that no trout could leap up. Although they used to try it every day, not one ever succeeded.



"And in Each Cañon was a Waterfall."

So it went on. A great many things happened in

other parts of the world. America had been discovered and the colonies were feeling their way toward the Pacific Ocean. And in the vanguard was the famous expedition of Lewis and Clarke, which went overland to the mouth of the river Columbia. John Colter was a hunter in this expedition, and by some chance he went across the mountains on the old trail of the Nez Percès Indians which leads across the Divide from the Missouri waters to those of the Columbia. When he came back from the Nez Percès trail he told most wonderful tales of what he had seen at the head of the Missouri. There were cataracts of scalding water which shot straight up into the air; there were blue ponds hot enough to boil fish; there were springs that came up snorting and steaming, and which would turn trees into stone; the woods were full of holes from which issued streams of sulphur; there were cañons of untold depth with walls of ashes full of holes which let off steam like a locomotive, and there were springs which looked peaceful enough, but which at times, would burst like a bomb.

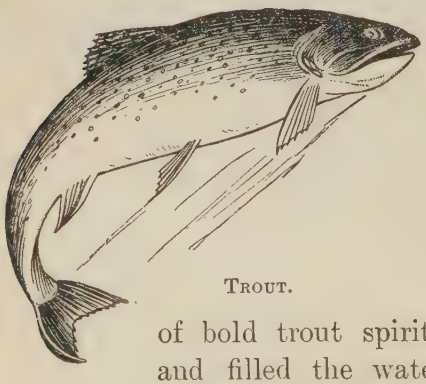
In short, every one laughed at Colter and his yarns, and this place where all lies were true was familiarly known as "Colter's Hell." But for once John Colter told the truth, and the truth could not easily be exaggerated. But no one believed him. When others who afterwards followed him over the Nez Percès trail told the same stories, people said they had been up to "Colter's Hell" and had learned to lie.

But, as time passed, other men told what they had seen, until, in 1870, a sort of official survey was made under the lead of Washburne and Doane. This party

got the general bearings of the region, named many of the mountains, and found so much of interest that the next year Dr. Hayden, the United States Geologist, sent out a party for systematic exploration. The Hayden party came up from Colorado on horseback, through dense and tangled forests, across mountain torrents, and other craggy peaks. The story of this expedition has been most charmingly told by its youngest member, another John Coulter. Professor Coulter was the botanist of the survey, and he won the first of his many laurels on this expedition. In 1872, acting on Hayden's report, Congress took the matter in hand and set apart this whole region as a "public park or pleasuring ground for the benefit and enjoyment of the people," and such it remains to this day.

But, while only of late this region has had a public history, the long-forgotten years between the Glacial period and the expedition of Lewis and Clarke were not without interest in the history of the trout. For all these years the fishes have been trying to mount the waterfalls in order to ascend to the plateau above. Year after year, as the spawning-time came on, they leaped against the falls of the Gardiner, the Gibbon, and the Firehole Rivers, but only to fall back impotent in the pools at their bases. But the mightiest cataract of all, the great falls of the Yellowstone, they finally conquered, and in this way it was done: not by the trout of the Yellowstone River, but by their brothers on the other side of the Divide. These followed up the Columbia to the head-waters of the Snake River, its great tributary, past the beautiful Heart Lake, and then on to the stream now called Pacific Creek, which

rises on the very crest of the Divide. In the space between this stream, which flows west to help form the Snake River, and a smaller stream now called Atlantic Creek, flowing down the east slope of the Divide, the great chain of the Rocky Mountains shrinks to a narrow plateau of damp meadow, not a fourth of a mile in width; and some years, when the snows are heavy and melt late in the spring, this whole region is covered with standing water. The trout had bided their time until they found it so, and now they were ready for action. Before the water was drained they had crossed the Divide and were descending on the Atlantic side toward the Yellowstone Lake. As the days went by, this colony of bold trout spirits grew and multiplied and filled the waters of the great clear lake, where their descendants remain to this day. And no other fishes — not the chub, nor the sucker, nor the white-fish, nor the minnow, nor the blob — had ever climbed Pacific Creek. None of them were able to follow where the trout had gone, and none of them have ever been seen in the Yellowstone Lake. What the trout had done in this lake — their victories and defeats, their struggles with the bears and pelicans, and with the terrible worm, joint enemy of trout and pelicans alike — must be left for another story.



Trout.

So the trout climbed the Yellowstone Falls by way

of the back staircase. For all we know, they have gone down it on the other side. And in a similar way, by stealing over from Blacktail Deer Creek, they overcame the Undine Falls in Lava Creek and passed its steep obsidian walls, which not all the fishes in the world could climb.

In the Gibbon River the cataracts have proved to the trout an impassible barrier; but, strangely enough, its despised associate, the sluggish, chunky blob, the little soft-bodied, smooth, black tadpole-like fellow, with twinkling eyes and a voracious appetite — a fish who cannot leap at all — has crossed this barrier. Hundreds of blob live under the stones in the upper reaches of the stream, the only fish in the Gibbon waters. There he is, and it is a standing puzzle even to himself to know how he got there. We might imagine, perhaps, that some far-off ancestor, some ancient Queen of the Blobs, was seized by an osprey and carried away in the air. Perhaps an eagle was watching and forced the osprey to give up its prey. Perhaps in the struggle the blob escaped, falling into the river above the falls, to form the beginning of the future colony. At any rate, there is the great impassable waterfall, the blob above it and below. The osprey has its nest on a broken pine tree, above the cataract, and its tyrant master, the bald eagle, watches it from a still higher crag whenever it goes fishing.

Two years ago the Hon. Marshall McDonald, whose duty as United States Fish Commissioner it is to look after the fishes wherever they may be, sent me to this country to see what could be done for his wards. It was a proud day when I set out from Mammoth Hot

Springs astride a black cayuse, or Indian pony, which answered to the name of Jump, followed by a long train of sixteen other cayuses of every variety of color and character, the most notable of all being a white pony called Tinker. At some remote and unidentified period of her life she had bucked and killed a tradesman who bestrode her against her will, and thereby, as in the old Norse legends, she has inherited his strength, his wickedness, and his name. And when, after many adventures, I came back from this strange land and told the story of its fishes other men were sent out from Washington with nets and buckets. They gathered up the trout and carried them to the rivers above the falls, and now all the brooks and pools of the old lava-bed, the fairest streams in the world, are full of their natural inhabitants.

THE COLORS OF ANIMALS

(From Chapters in Popular Natural History.)

By SIR JOHN LUBBOCK, BART., M.P., F.R.S., etc.

THE color of animals is by no means a matter of chance; it depends on many considerations, but in the majority of cases tends to protect the animal from danger by rendering it less conspicuous.

Perhaps it may be said that if coloring is mainly protective, there ought to be but few brightly colored animals. There are, however, not a few cases in which vivid colors are themselves protective. The kingfisher itself, though so brightly colored, is by no means easy to see. The blue harmonizes with the water, and the bird as it darts along the stream looks almost like a flash of sunlight; besides which, protection is not the only consideration. Let us now consider the prevalent colors of animals and see how far they support the rule.

Desert animals are generally the color of the desert. Thus, for instance, the lion, the antelope, and the wild

ass are all sand-colored. "Indeed," says Canon Tristram, "in the desert, where neither trees, brushwood, nor even undulation of the surface afford the slightest protection to its foes, a modification of color which shall be assimilated to that of the surrounding country is absolutely necessary. Hence, without exception, the upper plumage of every bird, whether lark, chat, sylvain, or sand grouse, and also the fur of all the smaller mammals and the skin of all the snakes and lizards, is of one uniform sand color."

It is interesting to note that, while the lion is sand-colored like the desert, the long, upright, yellow stripes of the tiger make it very difficult to see the animal among the long dry grasses of the Indian jungles in which it lives. The leopard, again, and other tree cats are generally marked with spots which resemble gleams of light glancing through the leaves.

The colors of birds are in many cases perhaps connected with the position and mode of construction of their nests. Thus, we know that hen birds are generally less brightly colored than the cocks, and this is partly, perhaps, because bright colors would be a danger to the hens while sitting on their eggs. When the nest is placed underground or in the hole of a tree, etc., we find it no longer to be such an invariable rule that the hen bird is dull-colored; but, on the contrary, she is then often as gaily colored as the male. Such, for instance, is the case with the hen kingfisher, which is one of the brightest of British birds and one of the very few which make their nests underground; the hen woodpecker, which is also gaily colored and builds in hollow trees, forms a second instance.

In the few cases where the hens are as conspicuously colored as the cocks, and yet the nest is open to view, we generally find that the hens are strong, pugnacious birds, and well able to defend themselves. There are even instances, though these are comparatively rare, in which the hens are more brilliantly colored than the cocks; and it is an interesting fact that it is then the cocks, and not the hens, which hatch the eggs.

It therefore seems to be a rule, with very few exceptions, that when both the cocks and hens are of strikingly gay or conspicuous colors, the nest is such as to conceal the sitting bird; while, whenever there is a striking contrast of colors, the nest is open and the sitting bird exposed to view.

Again, most fishes are dark above and pale below. This points to the same fact, for when one looks down into the dark water, the dark color of their backs renders them the less easy to distinguish; while, to an enemy looking up from below, the pale belly would be less conspicuous against the light of the sky. Those fishes which live deep down in the depths of the ocean present no such contrast between the upper and under surface. Many of the smaller animals which live in the sea are as transparent as glass, and are consequently very difficult to distinguish.

It is sometimes said that if animals were really colored with reference to concealment, sheep would be green, like grass. This, however, is quite a mistake. If they were green they would really be more easy to see. In the gray of the morning and the evening twilight, just the time when wild animals generally feed, gray and stone colors are most difficult to distinguish.

Sheep were originally mountain animals, and every one who has ever been on a mountain-side knows how difficult it is to distinguish a sheep, at some distance, from a mass of stone or rock.

It is, again, a great advantage to the rabbit and hare to be colored like earth; black or white rabbits are more easy to see, and consequently more likely to be killed. This, however, does not apply to those which are kept in captivity, and we know that tame rabbits are often black and white. Again, in the far north, where for months together the ground is covered with snow, the white color, which would be a danger here, becomes an advantage; and many Arctic animals, like the polar bear and polar hare, are white, while others, such as the mountain hare and ptarmigan, change their color, being brown in summer and white in winter. So are the Arctic fox and the ermine, to whom it is then an advantage to be white, not to avoid danger, but in order that they may be the more easily able to steal unperceived upon their prey.

Many of the cases in which certain insects escape danger by their similarity to plants are well known; the leaf insect and the walking-stick insect are familiar and most remarkable cases. The larvæ of insects afford, also, many interesting examples, and in other respects teach us, indeed, many instructive lessons. It would be a great mistake to regard them as merely preparatory stages in the development of the perfect insect. They are much more than this, for external circumstances act on the larvæ, as well as on the perfect insect: both, therefore, are liable to adaptation. In fact, the modifications which insect larvæ undergo

may be divided into two kinds — developmental, or those which tend to approximation to the mature form; and adaptational or adaptive, those which tend to suit them to their own mode of life.

It is a remarkable fact, that the forms of larvæ do not depend on those of the mature insect. In many cases, for instance, very similar larvæ produce extremely dissimilar insects. In other cases, similar, or comparatively similar, perfect insects have very dissimilar larvæ. Indeed, a classification of insects founded on larvæ would be quite different from that founded on the perfect insects. The group to which the bees, wasps, and ants belong, for instance, and which, so far as the perfect insects are concerned, form a very natural division, would be divided into two; or rather one portion of them — namely, the saw-flies — would be united to the butterflies and moths. Now, why do the larvæ of saw-flies differ from those of their allies, and resemble those of butterflies and moths? It is because their habits differ from those of ants and bees, and they feed on leaves like ordinary caterpillars.

In some cases the form changes considerably during the larval state. From this point of view, the transformations of a small beetle, called *Sitaris*, which have been carefully observed by M. Fabre, are peculiarly interesting.

The genus Sitaris, which is allied to the blister-fly and to the oil-beetle, is parasitic on a kind of solitary bee which excavates subterranean galleries, each leading to a cell. The eggs of the beetle, which are deposited at the entrance of the galleries made by the bees, are hatched at the end of September or beginning of Octo-

ber, and we might not unnaturally expect that the young larvæ, which are active little creatures with six serviceable legs, would at once eat their way into the cells of the bee. No such thing: till the month of April following they remain without leaving their birth-place, and consequently without food; nor do they in this long time change either in form or size. M. Fabre ascertained this, not only by examining the burrow of the bees, but also by direct observations of some young larvæ kept in captivity. In April, however, his captives at last awoke from their long lethargy, and hurried anxiously about their prisons. Naturally inferring that they were in search of food, M. Fabre supposed that this would consist either of the larvæ or pupæ of the bee, or of the honey with which it stores its cell. All three were tried without success. The first two were neglected; and the larvæ, when placed on the latter, either hurried away or perished in the attempt, being evidently unable to deal with the sticky substance. M. Fabre was in despair. The first ray of light came to him from our countryman Newport, who ascertained that a small parasite found on one of the wild bees was, in fact, the larva of the oil-beetle. The larvæ of Sitaris much resembled this larva. Acting on this hint, M. Fabre examined many specimens of the bee, and found on them at last the larvæ of his Sitaris. The males of the bee emerge from the pupæ sooner than the females, and M. Fabre ascertained that, as they come out of their galleries, the little Sitaris larvæ fasten upon them. Not, however, for long: instinct teaches them that they are not yet in the straight path of development; and, watching their opportunity, they

pass from the male to the female bee. Guided by these indications, M. Fabre examined several cells of the bee; in some, the egg of the bee floated by itself on the surface of the honey; in others, on the egg, as on a raft, sat the still more minute larva of the Sitaris. The mystery was solved. At the moment when the egg is laid, the Sitaris larva springs upon it. Even while the poor mother is carefully fastening up her cell, her mortal enemy is beginning to devour her offspring; for the egg of the bee serves not only as a raft, but as a repast. The honey, which is enough for either, would be too little for both; and the Sitaris, therefore, at its first meal, relieves itself from its only rival. After eight days the egg is consumed, and on the empty shell the Sitaris undergoes its first transformation, and makes its appearance in a very different form.

The honey, which was fatal before, is now necessary — the activity, which before was necessary, is now useless; consequently, with the change of skin, the active, slim larva changes into a white fleshy grub, so organized as to float on the surface of the honey, with the mouth beneath and the breathing-holes above the surface; for insects breathe, not as we do through the mouth, but through a row of holes arranged along the side. In this state it remains until the honey is consumed; then the animal contracts, and detaches itself from its skin, within which the further transformations take place. In the next stage the larva has a solid corneous envelope and an oval shape, and, in its color, consistency, and immobility, resembles the chrysalis of a fly. The time passed in this condition varies much. When it has

elapsed, the animal moults again, again changes its form; after this, it becomes a pupa, without any remarkable peculiarities. Finally, after these wonderful changes and adventures, in the month of August the perfect beetle makes its appearance.

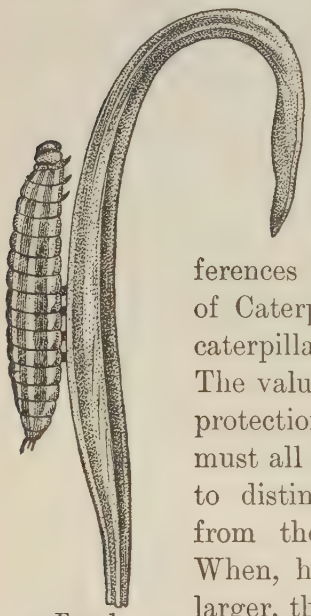


Fig. 1.
The Caterpillar of the Marbled White Butterfly (*Arge galathea*).

In fact, whenever in any group we find differences in form or color, we shall always find them associated with differences in habit. Let us take the case of Caterpillars. The prevailing color of caterpillars is green, like that of leaves. The value of this to the young insect, the protection it affords, are obvious. We must all have observed how difficult it is to distinguish small green caterpillars from the leaves on which they feed. When, however, they become somewhat larger, their form betrays them, and it is important that there should be certain marks to divert the eye from the outlines of the body. This is effected, and much protection is given, by longitudinal lines (Fig. 1), which accordingly are found on a great many caterpillars. These lines, both in color and thickness, much resemble some of the lines on leaves (those, for instance, of grasses), and also the streaks of shadow which occur among foliage. If this be the explanation of them, then they ought to be wanting, as a general rule, in very small caterpillars, and should prevail most among those which feed on or among grasses.

Now, similar lines occur on a great number of caterpillars belonging to most different groups of butterflies and moths, as you may see by turning over the illustrations of any monograph of the group. They exist among the Hawk-moths — as, for instance, in the Humming-bird Hawk-moth; they occur in many butterflies, especially in those which feed on grass; and in many moths. But you will find that the smallest caterpillars rarely possess these white streaks. As regards the second point, also, the streaks are generally wanting in caterpillars which feed on large-leaved plants. The *Satyridæ*, on the contrary, all possess them, and all live on grass. In fact we may say, as a general rule, that these longitudinal streaks only occur on caterpillars which live on or among narrow-leaved plants. As the insect grows, these lines often disappear on certain segments, and are replaced by diagonal lines. These diagonal lines (Fig. 2) occur in a great many caterpillars, belonging to the most distinct families of butterflies and moths. They come off just at the same angle as the ribs of leaves, and resemble them very much in general effect. They occur also especially on species which feed on large-leaved plants; and I believe I may say that though a great many species of caterpillars present these lines, they rarely, if ever, occur in species which live on grass; while, on

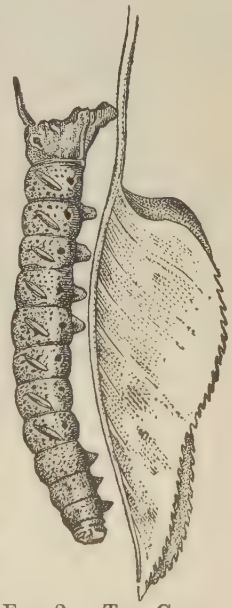


Fig. 2. — The Caterpillar of the Eyed Hawk-Moth (*Smerinthus ocellatus*).

the contrary, they are very frequent in those species which live on large-leaved plants.

It might at first be objected to this view that there are many cases, as in the Elephant-Hawk-moth, in which caterpillars have both. A little consideration, however, will explain this. In small caterpillars these oblique lines would be useless, because they must have some relation, not only in color, but in their distance apart, to the ribs of the leaves. Hence, while there are a great many species which have longitudinal lines when young, and diagonal ones when they are older and larger, there is not, I believe, a single one which begins with diagonal lines, and then replaces them with longitudinal ones. The disappearance of the longitudinal lines on those segments which have diagonal ones, is striking, where the lines are marked. It is an advantage, because white lines crossing one another at such an angle have no relation to anything which occurs in plants, and would make the creature more conspicuous. When, therefore, the diagonal lines are developed, the longitudinal ones often disappear. There is one other point in connection with these diagonal lines to which I must call your attention.

In many species they are white, but in some cases — as, for instance, in the beautiful green caterpillar of the Privet-Hawk-moth — the white streak is accompanied by a colored one, in that case lilac. At first we might think that this would be a disadvantage, as tending to make the caterpillar more conspicuous; and in fact, if we put one in full view — for instance, out on a table — and focus the eye on it, the colored lines are very striking. But we must remember that the

habit of the insect is to sit on the lower side of the leaf, generally near the middle rib, and in the subdued light of such a situation, especially if the eye be not looking exactly at them, the colored lines beautifully simulate a line of soft shadow, such as must always accompany a strong rib; and I need not tell any artist that the shadows of yellowish-green must be purplish. Moreover, any one who has ever found one of these large caterpillars will, I am sure, agree with me that it is surprising, when we consider their size and conspicuous coloring, how difficult it is to see them.

But though the prevailing color of caterpillars is green, there are numerous exceptions. In one great family of moths the prevailing color is brown. These caterpillars, however, escape observation by their great similarity to brown twigs — a resemblance which is heightened by their peculiar attitudes, and in many cases by the existence of warts or protuberances, which look like buds. Some, however, even of these caterpillars, when very young, are green. Again, some caterpillars are white. These feed on and burrow in wood. The Ringlet Butterfly also has whitish caterpillars, and this may at first sight appear to contradict the rule, since it feeds on grass. Its habit is, however, to keep at the roots by day, and feed only at night.

In various genera we find Black caterpillars, which are of course very conspicuous, and, so far as I know, not distasteful to birds. In such cases, however, it will be found that they are covered with hairs or spines, which protect them from most birds. In these species the bold dark color may be an advantage, by render-

ing the hair more conspicuous. Many caterpillars are black and hairy, but I do not know any large caterpillar which is black and smooth.

Brown caterpillars, also, are frequently protected by hairs or spines in the same way; but, unlike black ones, they are frequently naked. These fall into two principal categories: firstly, those which, like the Geometridæ, put themselves into peculiar and stiff attitudes, so that in form, color, and position they closely resemble bits of dry stick; and, secondly, those which feed on low plants, concealing themselves on the ground by day, and only coming out in the dark.

Yellow and yellowish-green caterpillars are abundant, and their color is a protection. Red and blue, on the contrary, are much less common colors, and are generally present as spots.

Moreover, caterpillars with red lines or spots are generally hairy, and this for the reason given above. Such species, therefore, would be avoided by birds. There are, no doubt, some apparent exceptions. The Swallow-tail Butterfly, for instance, has red spots and still is smooth; but as it emits a strongly-scented liquid when alarmed, it is probably distasteful to birds. I cannot recall any other case of a British caterpillar which has conspicuous red spots or lines, and yet is smooth.

Blue is, among caterpillars, even a rarer color than red. Indeed, among our larger larvæ, the only cases I can recall are the Lappets, which have two conspicuous blue bands, the Death's-head Moth, which has broad diagonal bands, and two of the Hawk-moths, which have two bright blue oval patches on the third

segment. The Lappets are protected by being hairy, but why they have the blue bands I have no idea. It is interesting, that both the other species frequent plants which have blue flowers. The peculiar hues of the Death's-head caterpillar, which feeds on the potato, unite so beautifully the brown of the earth, the yellow and green of the leaves, and the blue of the flowers, that, in spite of its size, it can scarcely be perceived unless the eye be focussed exactly upon it.

The Oleander Hawk-moth is also an interesting case. Many of the Hawk-moth caterpillars have eye-like spots, to which I shall have to allude again presently. These are generally reddish or yellowish, but in this species, which feeds on the periwinkle, they are bright blue, and in form as well as color closely resemble the blue petals of that flower. One other species, the Sharp-winged Hawk-moth, also has two smaller blue spots, with reference to which I can make no suggestion. It is a very rare species, and I have never seen it. Possibly, in this case, the blue spots may be an inherited character, and have no reference to the present habits. They are, at any rate, quite small.

No one who looks at any representations of Hawk-moth caterpillars can fail to be struck by the peculiar coloring of those belonging to the Pine Moth, which differ in style of coloring from all other sphinx larvæ, having longitudinal bands of brown and green. Why is this? Their *habitat* is different. They feed on the leaves of the pinaster, and their peculiar coloring offers a general similarity to the brown twigs and narrow green leaves of a conifer. There are not many species of butterflies or moths which feed on the pine,

but there are a few: and most, if not all of them, have a very analogous style of coloring to that of the Pine Moth, while the latter has also tufts of bluish-green hair which singularly mimic the leaves of the pine. It is still more remarkable that in a different order of insects we again find species — for instance one of the saw-flies — which live on the pine, and in which the same style of coloring is repeated.

Let us now take a single group, and see how far we can explain its various colors and markings, and what are the lessons which they teach us. For this purpose, I think I cannot do better than select the larvæ of the Hawk-moths, which have just been the subject of a masterly work by Dr. Weissmann, from which most of the following facts are taken.

The caterpillars of this group are very different in color — green, white, yellow, brown, sometimes even gaudy, varied with spots, patches, streaks, and lines. Now, are these differences merely casual and accidental, or have they a meaning and a purpose? In many, perhaps in most cases, the markings serve for the purpose of concealment. When, indeed, we see caterpillars represented on a white sheet of paper, or if we put them on a plain table, and focus the eye on them, the colors and markings would seem, if possible, to render them even more conspicuous; but amongst the intricate lines and varied colors of foliage and flowers, and if the insect be a little out of focus, the effect is very different.

Let us begin with the Elephant Hawk-moth. The caterpillars (Fig. 3), as represented in most entomological works, are of two varieties, most of them brown, but some green. Both have a white line on the three

first segments; two remarkable eye-like spots on the fourth and fifth, and a very faint median line; and are rather more than four inches long. I will direct your attention specially, for the moment, to three points: — What do the eye-spots and the faint lateral line mean?

Fig. 3. — The Caterpillar of the Elephant Hawk-Moth (*Chœrocampa elpenor*). Full grown. Natural size.

and why are some green and some brown, offering thus such a marked contrast to the leaves of the small epilobe on which they feed? Other questions will suggest themselves later. I must now call your attention to the fact, that when the caterpillars first quit the egg, and come into the world (Fig. 4), they are quite different in appearance, being, like so many other small caterpillars, bright green, and almost exactly the color of the leaves on which they feed. That this color is not the necessary or direct consequence of the food, we see from the case of quadrupeds, which, as I need scarcely say, are never green. It is, however, so obviously a protection to small caterpillars, that this explanation of their green color suggests itself to every one.

Fig. 4. — The Caterpillar of the Elephant Hawk-moth (*Chœrocampa elpenor*). First stage.

After five or six days, and when they are about a quarter of an inch in length, they go through their first moult. In their second stage (Fig. 5), they have two white lines, stretching along the body from the horn to the head; and after a few days (Fig. 6), but not at first, traces of the eye-spots appear on the fourth and fifth segments, shown by a slight wave in the upper line. After another five or six days, and when about half an inch in length, our caterpillars moult again. In their third stage (Fig. 7), the commencement of the eye-spots is more marked, while, on the contrary, the lower longitudinal line has disappeared. After another moult (Fig. 8), the eye-spots are still more distinct, the white gradually becomes surrounded by a black line, while in the next stage (Fig. 9) the centre becomes somewhat violet. The white lines have almost or entirely disappeared, and in some specimens faint diagonal lines make their appearance. Some few assume a brownish tint, but not many. A fourth moult takes place in seven or eight days, and when the caterpillars are about an inch and a half in length. Now, the differ-

Fig. 5. — The Caterpillar of the Elephant Hawk-moth (*Chærocampa elpenor*). Second Stage.

Fig. 6. — The Caterpillar of the Elephant Hawk-moth (*Chærocampa elpenor*). Just before the second moult.

Fig. 7. — The Caterpillar of the Elephant Hawk-moth (*Chærocampa elpenor*). Third Stage.

ence shows itself still more between the two varieties, some remaining green, while the majority become brown. The eye-spots are more marked, and the pupil more distinct, the diagonal lines plainer, while the white line is only indicated on the first three, and on

Fig. 8. — The Caterpillar of the Elephant Hawk-moth (*Chœrocampa elpenor*). Fourth Stage.

the eleventh segment. The last stage (Fig. 9) has been already described.

Now, the principal points to which I wish to draw attention are (1) the green color, (2) the longitudinal lines, (3) the diagonal lines, (4) the brown color, and (5) the eye-spots.

As regards the first three, however, I think I need say no more. The value of the green color to the

Fig. 9. — The Caterpillar of the Elephant Hawk-Moth (*Chœrocampa elpenor*). Fifth Stage.

young larva is obvious; nor is it much less clear that when the insect is somewhat larger, the longitudinal lines are a great advantage, while subsequently diagonal ones become even more important.

The next point is the color of the mature caterpillars. We have seen that some are green, and others

brown. The green ones are obviously merely those which have retained their original color. Now for the brown color. This probably makes the caterpillar even more conspicuous among the green leaves than would otherwise be the case. Let us see, then, whether the habits of the insect will throw any light upon the riddle. What would you do if you were a big caterpillar? Why, like most other defenceless creatures, you would feed by night, and lie concealed by day. So do these caterpillars. When the morning light comes, they creep down the stem of the food plant, and lie concealed among the thick herbage, and dry sticks and leaves, near the ground; and it is obvious that under such circumstances the brown color really becomes a protection. It might indeed be argued that the caterpillars, having become brown, concealed themselves on the ground; and that we were, in fact, reversing the state of things. But this is not so; because, while we may say, as a general rule, that (with some exceptions due to obvious causes) large caterpillars feed by night and lie concealed by day, it is by no means always the case that they are brown; some of them still retaining the green color. We may then conclude that the habit of concealing themselves by day came first, and that the brown color is a later adaptation. It is, moreover, interesting to note that while the caterpillars which live on low plants often go down to the ground and turn brown, those which feed on large trees or plants remain on the under side of the leaves, and retain their green color.

Thus, in the Eyed Hawk-moth, which feeds on the willow and sallow; the Poplar Hawk-moth, which feeds

on the poplar; and the Lime Hawk-moth, which frequents the lime, the caterpillars all remain green; while in those which frequent low plants, such as the Convolvulus Hawk-moth, which frequents the convolvulus; the Oleander Hawk-moth, which feeds in this country on the periwinkle; and other species, most of the caterpillars turn brown. There are, indeed, some caterpillars which are brown, and still do not go down to the ground — as, for instance, those of the Geometridæ generally. These caterpillars, however, as already mentioned, place themselves in peculiar attitudes, which, combined with their brown color, make them look almost exactly like bits of stick or dead twigs.

The last of the five points to which I called your attention was the eye-spots. In some cases, spots may serve for concealment, by resembling the marks on dead leaves. In one species, which feeds on the hippophæ, or sea buckthorn, a gray-green plant, the caterpillar also is a similar gray-green, and has, when full grown, a single red spot on each side — which, as Weissmann suggests, at first sight much resembles in color and size one of the berries of the hippophæ. This might, at first, be supposed to constitute a danger, and therefore to be a disadvantage; but the seeds, though present, are not ripe, and consequently are not touched by birds. Again, in another caterpillar, there is an eye-spot on each segment, which mimics the flower of the plant on which it feeds. White spots, in some cases, also resemble the spots of light which penetrate foliage. In other instances, however, and at any rate in our Elephant Hawk-moth, the eye-spots certainly render the insect more conspicuous.

Now in some cases, this is an advantage, rather than a drawback. Suppose that from the nature of its food, from its being covered with hair, or from any other cause, a small green caterpillar were very bitter, or disagreeable or dangerous as food, still, in the number of small green caterpillars which birds love, it would be continually swallowed by mistake. If, on the other hand, it had a conspicuous and peculiar color, its evil taste would serve to protect it, because the birds would soon recognize and avoid it, as has been proved experimentally. I have already alluded to a case of this among the Hawk-moths, in a species which, feeding on euphorbia, with its bitter milky juice, is very distasteful to birds, and is thus actually protected by its bold and striking colors. The spots on our Elephant Hawk-moth caterpillar do not admit of this explanation, because the insect is quite good to eat — I mean, for birds. We must, therefore, if possible, account for these spots in some other way. There can, I think, be little doubt that Weissmann is right when he suggests that the eye-spots actually protect the caterpillar, by frightening its foes.

Every one must have observed that these large caterpillars — as, for instance, that of the small Elephant Hawk-moth (Fig. 10) — have a sort of uncanny poisonous appearance; that they suggest a small thick snake or other evil beast, and the so-called "eyes' do much to increase the deception. Moreover, the segment on which they are placed is swollen, and the insect, when in danger, has the habit of retracting its head and front segments, which gives it an additional resemblance to some small reptile. That small birds are, as a matter

of fact, afraid of these caterpillars (which, however, I need not say, are in reality altogether harmless), Weissmann has proved by actual experiment. He put one of these caterpillars in a tray in which he was accustomed to place seed for birds. Soon a little flock of sparrows and other small birds assembled to feed as usual. One of them lit on the edge of this tray, and was just going to hop in, when she spied the caterpillar. Immediately she began bobbing her head up and down, but was afraid to go nearer. Another joined her, and then another, until at last there was a little company of ten or twelve birds, all looking on in astonishment, but not one ventured into

Fig. 10. — The Caterpillar of the Small Elephant Hawk-moth (*Chœrocampa porcellus*).

the tray; while one bird, which lit in it unsuspectingly, beat a hasty retreat in evident alarm, as soon as she perceived the caterpillar. After watching for some time, Weissmann removed it, when the birds soon attacked the seeds. Other caterpillars also are probably protected by their curious resemblance to spotted snakes.

Moreover, we may learn another very interesting lesson from these caterpillars. They leave the egg, as we have seen, a plain green, like so many other caterpillars, and gradually acquire a succession of markings, the utility of which I have just attempted to explain. The young larva, in fact, represents an

old form, and the species, in the lapse of ages, has gone through the stage which each individual now passes through in a few weeks. Thus, the caterpillar of *Chærocampa porcellus*, a species very nearly allied to the Elephant Hawk-moth, passes through almost exactly the same stages as that species. But it leaves the egg with a subdorsal line, which the caterpillar of the Elephant Hawk-moth does not acquire until after its first moult. No one can doubt, however, that there was a time when the new-born caterpillars of the small Elephant Hawk-moth were plain green, like those of the large one. Again, if we compare the mature caterpillars of this group of Hawk-moths, we shall find there are some forms which never develop eye-spots, but which, even when full grown, correspond to the second stage of the Elephant Hawk-moth. Here, then, we seem to have species still in the stage which the Elephant Hawk-moth must have passed through long ago.

The genus *Deilephila*, of which we have three species — the Euphorbia Hawk-moth, the Galium Hawk-moth, and the Rayed Hawk-moth — is also very instructive. The caterpillar of the Euphorbia Hawk-moth begins life of a clear green color, without a trace of the subsequent markings. After the first moult, however, it has a number of black patches, a white line, and a series of white dots, and has, therefore, at one bound, acquired characters which in the Elephant Hawk-moth, as we have seen, were only very gradually assumed. In the third stage, the line has disappeared, leaving the white spots. In the fourth, the caterpillars have become very variable, but are generally much darker than

before, and have a number of white dots under the spots. In the fifth stage, there is a second row of white spots under the first. The caterpillars not being good to eat, there is, as has been already pointed out, no need for, or attempt at, concealment. Now if we compare the mature caterpillars of other species of the genus, we shall find that they represent phases in the development of the Euphorbia Hawk-moth. The Sea Buckthorn Hawk-moth, for instance, even when full grown, is a plain green, with only a trace of the line, and corresponds, therefore, with a very early stage of the Euphorbia Hawk-moth; there is another species found in South Russia, which has the line, and represents the second stage of the Euphorbia Hawk-moth; another has the line and the row of spots, and represents, therefore, the third stage; lastly, there are some which have progressed further, and lost the longitudinal line, but they never acquire the second row of spots which characterizes the last stage of the Euphorbia Hawk-moth.

Thus, then, the individual life of certain caterpillars gives us a clue to the history of the species in past ages.

For such inquiries as this, the larvæ of Lepidoptera are particularly suitable, because they live an exposed life; because the different species, even of the same genus, often feed on different plants, and are therefore exposed to different conditions; and last, not least, because we know more about the larvæ of the butterflies and moths than about those of any other insects. The larvæ of ants all live in the dark; they are fed by the perfect ants, and being therefore all subject to very

similar conditions, are all very much alike. It would puzzle even a good naturalist to determine the species of an ant larva, while, as we all know, the caterpillars of butterflies and moths are as easy to distinguish as the perfect insects; they differ from one another as much as, sometimes more than, the butterflies and moths themselves.

There are five principal types of coloring among caterpillars. Those which live inside wood, or leaves, or underground, are generally of a uniform pale hue; the small leaf-eating caterpillars are green, like the leaves on which they feed. The other three types may, to compare small things with great, be likened to the three types of coloring among cats. There are the ground cats, such as the lion or puma, which are brownish or sand color, like the open places they frequent. So also caterpillars which conceal themselves by day at the roots of their food-plant, tend, as we have seen, even if originally green, to assume the color of earth. Nor must I omit to mention the *Geometridæ*, to which I have already referred, and which, from their brown color, their peculiar attitudes, and the frequent presence of warts or protuberances, closely mimic bits of dry stick. That the caterpillars of these species were originally green, we may infer from the fact that some of them at least are still of that color when first born.

Then there are the spotted or eyed cats, such as the leopard, which live among trees; and their peculiar coloring renders them less conspicuous by simulating spots of light which penetrate through foliage. So also many caterpillars are marked with

spots, eyes, or patches of color. Lastly, there are the jungle cats, of which the tiger is the typical species, and which have stripes, rendering them very difficult to see among the brown grass which they frequent. It may, perhaps, be said that this comparison fails, because the stripes of tigers are perpendicular, while those of caterpillars are either longitudinal or oblique. This, however, so far from constituting a real difference, confirms the explanation; because in each case the direction of the lines follows that of the foliage. The tiger, walking horizontally on the ground, has transverse bars; the caterpillar, clinging to the grass in a vertical position, has longitudinal lines; while those which live on large-veined leaves have oblique lines, like the oblique ribs of the leaves.

Red and blue are rare colors among caterpillars. Omitting minute dots, we have six species more or less marked with red or orange. Of these, two are spiny, two hairy, and one protected by scent-emitting tentacles. The orange medio-dorsal line of the Bedford Butterfly is not very conspicuous, and has been omitted in some descriptions. Blue is even rarer than red; in fact, none of our butterfly larvæ can be said to exhibit this color.

Now let us turn to the moths. I have taken all the larger species, amounting to rather more than one hundred and twenty; out of which sixty-eight are hairy or downy; and of these forty-eight are marked with black or gray, fifteen brown or brownish, two yellowish-green, one bluish-gray, one striped with yellow and black, and one reddish-gray. There are two

yellowish-green hairy species, which might be regarded as exceptions: one, that of the Five-spotted Burnet-moth, is marked with black and yellow, and the other is variable in color, some specimens of this caterpillar being orange. This last species is also marked with black, so that neither of these species can be considered of the green color which serves as a protection. Thus, among the larger caterpillars, there is not a single hairy species of the usual green color. On the other hand, there are fifty species with black or blackish caterpillars, and of these forty-eight are hairy or downy.

In ten of our larger moths the caterpillars are more or less marked with red. Of these, three are hairy, one is an internal feeder, four have reddish lines, which probably serve for protection by simulating lines of shadow, and one, the Euphorbia Hawk-moth, is inedible. The last, the striped Hawk-moth, is rare, and I have never seen the caterpillar; but to judge from figures, the reddish line and spots would render it, not more, but less conspicuous amongst the low herbage which it frequents.

Seven species only of the larger moths have any blue; of these, four are hairy, the other three are Hawk-moths. In one, the Death's Head, the violet color of the side stripes certainly renders the insect less conspicuous among the flowers of the potato, on which it feeds. In the Oleander Hawk-moth there are two blue patches, which, both in color and form, curiously resemble the petals of the periwinkle, on which it feeds. In the third species, the small Elephant Hawk-moth, the bluish spots form the centres of the above-mentioned eye-like spots.

In one family, as already mentioned, the caterpillars are very often brown, and closely resemble bits of stick, the similarity being much increased by the peculiar attitudes they assume. On the other hand, the large brown caterpillars of certain Hawk-moths are night feeders, concealing themselves on the ground by day; and it is remarkable that while those species, such as the Convolvulus Hawk-moth, which feed on low plants, turn brown as they increase in age and size, others, which frequent trees, and cannot therefore descend to the ground for concealment, remain green throughout life. Omitting these, there are among the larger species, seventeen which are brown, of which twelve are hairy, and two have extensile caudal filaments. The others closely resemble bits of stick, and place themselves in peculiar and stiff attitudes.

And thus, summing up the caterpillars, both of butterflies and moths, out of eighty-eight spiny and hairy species, only one is green, and even this may not be protectively colored, since it has conspicuous yellow warts. On the other hand, a very great majority of the black and brown caterpillars, as well as those more or less marked with blue and red, are either hairy or spiny, or have some special protection.

Here, then, I think we see reasons, for many at any rate, of the variations of color and markings in caterpillars, which at first sight seem so fantastic and inexplicable. I should, however, produce an impression very different from that which I wish to convey, were I to lead you to suppose that all these varieties have been explained, or are understood. Far from it; they still offer a large field for study; nevertheless, I ven-

ture to think the evidence now brought forward, however imperfectly, is at least sufficient to justify the conclusion that there is not a hair or a line, not a spot or a color, for which there is not a reason — which has not a purpose or a meaning in the economy of nature.

PROTECTIVE RESEMBLANCES IN SPIDERS

By ELIZABETH G. PECKHAM.[1]

THERE are, among spiders, two forms of protective modification: the first, including all cases of protective resemblance to vegetable and inorganic things — that is, all modifications of color or of color and form that tend to make them inconspicuous in their natural relations — I shall call direct protection. The second form, which I shall call indirect protection, includes two classes, the spiders which are specially protected themselves and those which mimic other creatures which are specially protected.

Spiders are specially protected when they become inedible through the acquisition of hard plates and sharp spines. The modification of form is frequently accompanied by conspicuous colors, which warn their enemies that they belong to an unpalatable class.

The second class of indirectly protected spiders —

[1] Abbreviated from the occasional Papers of the Natural History Society of Wisconsin, Vol. I., 1889. By permission.

those that mimic specially protected creatures — presents some difficulties, since it is not always easy to determine whether the purpose of mimicry is protection or the capture of prey. The resemblance may, as is frequently the case in direct protection, serve both purposes.

In looking for instances of protective form and color among spiders we encounter one difficulty at the outset. The meaning of a protective peculiarity can be determined only when the animal is seen in its natural home. The number of strangely modified forms depicted in descriptive works on spiders is enormous. Bodies are twisted, elongated, inflated, flattened, truncated, covered with tubercles or spines, enclosed within chitinous plates, colored like bark, like lichens, like flowers of every imaginable hue, like bird droppings, like sand or stones, and in every one of these modifications there is doubtless an adaptation of the spider to its surroundings which, when it is studied out of its natural relations, we can only guess at.

It has been well said that in these protective resemblances those features of the portrait are most attended to by nature which produce the most effective deception when seen in nature; the faithfulness of the resemblance being much less striking when seen in the cabinet. . . .

Direct Protection. Resemblances to Vegetable and Inorganic Things. — As a general rule the forms and colors of spiders are adapted to render them inconspicuous in their natural homes. Bright colored spiders, . . . either keep hidden away or are found upon flowers whose tints harmonize with their own.

This rule, while it has numerous exceptions, is borne out by the great majority of cases. A good illustration is found in the genus Uloborus, of which the members bear a deceptive resemblance to small pieces of bark, or to such bits of rubbish as commonly become entangled in old deserted webs. The only species in our neighborhood is Uloborus plumipes, which I have almost invariably found building in dead branches, where its disguise is more effective than it would be among fresh leaves. The spider is always found in the middle of the web, with its legs extended in a line with the body. There has been, in this species, a development along several lines, resulting in a disguise of considerable complexity. Its form and color make it like a scrap of bark, its body being truncated and diversified with small humps, while its first legs are very uneven, bearing heavy fringes of hair on the tibia and having the terminal joints slender. Its color is a soft wood-brown or gray, mottled with white. It has the habit of hanging motionless in the web for hours at a time, swaying in the wind like an inanimate object. The strands of its web are rough and inelastic, so that they are frequently broken; this gives it the appearance of one of those dilapidated and deserted webs in which bits of wind-blown rubbish are frequently entangled. . . .

Out of seven examples of the species taken during one summer, five were found in dead tamarack branches, one on a dead bush, and the seventh, an interesting variety, under the eaves of a porch. My eye was caught by what seemed to be a string of eleven cocoons (it is not common to see more than four in a web).

On attempting to take them down I was surprised to see one of the supposed cocoons begin to shake the web violently. Ten were what they seemed to be, but the eleventh was the mother spider, whose color and general appearance was exactly like that of the little cases that she had made for her eggs. . . .

Fig. 1. — Cærostris Mitralis (from Vinson).

We come now to a large and interesting class in genus Epeira. I refer to those species, mostly nocturnal, which are protected during the day, not by hiding in crevices, nor in any way actually getting out of sight, but by the close resemblance which they bear to the bark of the trees to which they cling. This resemblance is brought about in two ways; through their color, which is like that of wood or lichens, and through their tuberculated and rugose forms, which resemble rough bark.

Fig. 2. — Cærostris Mitralis, in profile (from Vinson).

One of the most remarkable of these forms is C. mitralis, a Madagascar species, which, looked at in profile, probably resembles a woody knot. The abdomen is divided into two divergent cones (Fig. 1). The entire upper surface of the body is covered with conical elevations, which render it rough and uneven; the sides of the abdomen are made up of several layers, which form stages, one above another, like the ridges of bark on a woody excrescence. The legs, formed of wide, flattened plates,

make the base. The color of the spider is yellowish-gray, varied with white and dark reddish-brown. It has the habit of perching on a branch and clasping it like a bird, so that the elaborate modification of form, which would be useless if the spider hung exposed in the web, is made as effective as possible.

To take an example nearer home, E. infumata is a large, round-bodied spider, with two humps on the abdomen, which Emerton describes from New England as being brown, mottled with white and black; he adds that when it draws in its feet it looks like a lump of dirt. Infumata, in Wisconsin, has always a good deal of bluish-green on the upper surface of the abdomen. This may be a variety which has been so developed as to resemble the lichens which cover the tree to which it clings. It is one of the spiders which bear a good deal of handling without uncurling its legs, or showing any sign of life. Its humpy form and its color give it a very inanimate appearance. It is rather common in our neighborhood and may be caught in the late twilight while building its web, but to search for it in the daytime, even among the trees that it most frequents, is an almost hopeless task. A more grotesque form is E. stellata, in which the abdomen has not two, but twelve or fifteen humps. These are so disposed that the edge of the abdomen, all around, is scalloped. The colors are light and dark brown, modified by gray and white hairs. This spider remains motionless during the daytime, keeping its legs drawn up to its body. It is common on grass and low bushes. It is not found in Wisconsin, but the description of it suggests a resemblance to a piece of dead leaf.

There are many other spiders in this genus that have humps and are colored in brown, gray or dull yellow, as nordmanii, angulata, solitaria, etc. It is an almost universal habit among the Epeiridæ to drop to the ground when threatened, and when a humped gray or brown spider drops to the ground and draws in its legs it is nearly indistinguishable from the lumps of earth, sticks and stones that surround it.

One of the Theridiidæ which has the same protection is Ulesanis americana (Fig. 3). The abdomen, which covers the cephalothorax nearly to the eyes, has a prominent hump in the middle of the back and four or five others behind. Its color is in shades of brown and yellow.

Fig. 3. — Ulesanis americana (from Emerton).

Analogous to the humped Epeiridæ is Thomisus foka, of Madagascar, a spider which is regarded with great terror by the natives, as being so poisonous that even its breath is deadly. They say that cattle, when about to lie down, look carefully about to see if one of these spiders is in the neighborhood. This dread is, no doubt, inspired by the strange and uncanny aspect of a perfectly harmless creature. It has a rugose, tuberculated body of trapezoid form, the colors being brown and reddish, while the whole aspect is crab-like. The thick, short legs are reddish, covered with tubercules. The secret of its strange form is made clear when we learn that it resembles in color and general appearance the fruit of Hymenæa verrucosa, a tree common in the forests where this spider is found.

Among the curious forms which must have been developed through advantageous variation, but which we are unable to explain, is Eriauchenus workmanni (Fig. 4).

Fig. 4. — Eriauchenus Workmanni (from Cambridge).

Epeira prompta, a variety of parvula, is a common spider in the State of Wisconsin. It is most frequently seen on cedar bushes, where its color harmonizes with that of the foliage and fruit. During the day it usually rests on a branch near its web. The back of the abdomen is of a peculiar bluish-green, exactly like that of the lichens growing on tree trunks. The bluish color is broken by waving black lines which imitate the curling edges of the lichens. The one represented in the plate was found on an old cedar which was covered with lichens. It was kept for two weeks in a glass-covered box, where it spent most of the time crouching in a corner. It built no web, but spun some irregular lines to run about on. It ate gnats, flies, and once a little jumping spider, S. pulex, which we were keeping in the same box, leaping upon its prey, as noted by Hentz, like an Attus. This seems a curious habit to be acquired by an Epeirid, since spiders, as we have noticed among our captives, are usually dependent for food upon what is caught in their webs. Prompta moves awkwardly, but very rapidly.

Drapetisca socialis, while quite a different looking spider, is protected in the same way — by its resemblance to the bark upon which it lives. Emerton speaks of finding it on the bark of spruce trees, which it "closely resembles in color." Menge says that it is

common in Prussia, where it is seen in great numbers on fir trees, whose spotted bark it resembles in color, so that it is not easily seen. We have found them, most commonly, upon birch trees, and in this situation their color adaptation is perfect. Both the spider and the peeling bark of the tree are of a light silvery brown, covered with little blackish marks. On the bark these marks are, of course, irregular, while on the spider they form a pattern made up of straight and curved lines and dots, the legs being silvery, barred with blackish.

Another little Theridion that is found on birch bark has the same colors arranged a little differently. The abdomen above has a large and peculiarly irregular black patch, which shades off into mottled brown and black on the sides and below. The cephalothorax has stripes of brown and black, and the legs are barred with light and dark brown.

Spiders that live upon walls, fences, tree trunks, or on the ground harmonize in color with the surfaces upon which they are found, being usually gray, brown or yellow, mottled with black and white. This proposition is so well established as to need but few illustrations. The Theridiidæ furnish many examples, as T. murarium, a gray spider varied with black and white, said by Emerton to live usually "under stones and fences, where it is well concealed by its color"; and Lophocarenum rostratum, a yellowish-brown spider, found among leaves on the ground. Among the Attidæ bright sexual coloring often gains the ascendancy over the protective tints, yet this family gives us good examples in such species as M. familiaris and S. pulex.

To these may be added an as yet undescribed species which we discovered last season in a neighborhood that we had searched thoroughly for eight summers. We found the new spider in great numbers, but could only detect it by a close scrutiny of the rail fences on which it lived, its color being dark gray. . . .

The last instance that I shall cite is a predaceous spider which is disguised from both its enemies and its prey by an elaborate combination of form, color, position, and character of web. I refer to Ornithoscatoïdes decipiens (Fig. 5), first described by Forbes and afterwards by Cambridge, the latter author giving in the same paper descriptions of three other species of the same genus, whose habits have not been noted, but whose protection is evidently of the same order as that of decipiens. I give Forbes's interesting account of his capture of decipiens, quoting also the remarks by which Cambridge prefaces his description, since his explanation of the gradual development, through Natural Selection, of the spider's deceptive appearance applies as well to all the cases of protective disguise which have been here enumerated.

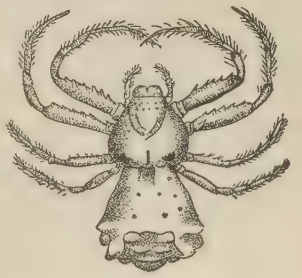


Fig. 5.
Ornithoscatoïdes decipiens
(from Cambridge).

The capture is described as follows : —

"On June 25th, 1881, in the forest near the village of Lampar, on the banks of the Moesi river in Sumatra, while my 'boys' were procuring for me some botanical specimens from a high tree, I was rather dreamily looking on the shrubs before me, when I became conscious

of my eyes resting on a bird-excreta-marked leaf. How strange, I thought, it is that I have never got another specimen of that curious spider I found in Java which simulated a patch just like this! I plucked the leaf by the petiole while so cogitating, and looked at it half listlessly for some moments, mentally remarking how closely that other spider had copied nature, when, to my delighted surprise, I discovered that I had actually secured a second specimen, but the imitation was so exquisite that I really did not perceive how matters stood for some moments. The spider never moved while I was plucking or twirling the leaf, and it was only when I placed the tip of my little finger on it, that I observed that it was a spider, when it, without any displacement of itself, flashed its falces into my flesh.

"The first specimen I got was in W. Java, while hunting one day for Lepidoptera. I observed a specimen of one of the Hesperidæ sitting, as is often a custom of theirs, on the excreta of a bird on a leaf; I crept near it, intending to examine what they find in what one is inclined to consider incongruous food for a butterfly. I approached nearer and nearer, and at last caught it between my fingers, when I found that it had as I thought become glued by its feet to the mass; but on pulling gently the spider, to my amazement, disclosed itself by letting go its hold: only then did I discover that I was not looking on a veritable bird's excreta. . . . The spider is in general color white, spotted here and there with black; on the underside its rather irregularly shaped and prominent abdomen is almost all white, of a pure chalk white; the angles of

the legs are, however, shining jet-black. The spider does not make an ordinary web, but only the thinnest film on the surface of the leaf. The appearance of the excreta rather recently left by a bird on a leaf is well known. There is a pure white deposit in the centre, thinning out round the margin, while in the central mass are dark portions variously disposed; as the leaf is rarely horizontal, the more liquid portions run for some distance. Now, this spider one might almost imagine to have in its rambles 'marked and inwardly discerned' what it had observed, and to have set about practising the 'wrinkles' gained; for it first weaves a small, irregular patch of white web on some prominent leaf, then a narrow streak laid down towards its sloping margin ending in a small knob; it then takes its place on the centre of the irregular spot on its back, crosses its black-angled legs over its thorax, and waits. Its pure white abdomen represents the central mass of the bird's excreta, the black legs the dark portions of the slime, while the web above described which it has spun represents the more watery marginal part (become dry), even to the run-off portion with the thickened knob (which was not accidental, as it occurred in both cases), like the residue which semi-fluid substances ending in a drop leave on evaporation. It keeps itself in position on its back by thrusting under the web below it the spines with which the anterior upper surfaces of the legs are furnished." . . .

Protective Habits. — Going along with these forms of protective resemblance, we find certain habits which sometimes serve independently to protect the spider, but oftener are supplemental to color and form. Many

species hide in crevices or in leaves which they roll up and bind together at the edges. In the Epeiridæ some are like thaddeus, which makes a little tent of silk under a leaf near its web. The young thaddeus also makes a tent, but spins its little geometrical web on the under side of the leaf, the edges being bent downward. E. insularis has the more common habit of forming its tent by drawing the edges of two or three leaves together with strands of web; in this it sits all day, but at night descends and occupies the centre of the web during the hours of darkness. I have often found it in this position when hunting nocturnal species by lantern light. It is probable that in tropical countries the monkeys, and perhaps the birds, which devour these large Epeiridæ have learned to recognize their webs, which are very large and conspicuous, and to trace them to their hiding places close by; and thus may have arisen the curious habit noticed by Vinson as possessed by E. nocturna and E. isabella of destroying the web each morning and rebuilding it at night; the spider in this way gaining greater security from diurnal enemies.

Atypus abbotii builds a purse-shaped tube which is found attached to the bark of trees, and which has the external surface dark and covered with sand. The trap-doors which close the nest of some of the Territelariæ are wonderful examples of protective industry. They fit with such absolute accuracy into the openings of the nests and are so covered on the upper side with moss, earth, lichens, etc., as to be indistinguishable from the surrounding surface.

The rectilinear lines which are stretched in front of

the webs of many Epeirids are useful in taking and sending on to the spider the shock which tells of an approaching enemy. Some spiders, when danger threatens, shake the web so violently as to grow indistinct to the eye, and others, as Pholcus atlanticus, hang by the legs and whirl the body rapidly with the same bewildering result. . . .

A habit common to many spiders, especially among the Epeiridæ, is that of dropping to the ground at the approach of danger and resting motionless among the dirt, sticks, leaves, etc., which they resemble in color. The holding of the body in some peculiar position, as in Uloborus, Hyptioides, and the flower-like Thomisidæ, is a necessary accompaniment to the color modification.

The cocoons of spiders are seldom left exposed and unprotected. We find them in corners and crevices, concealed in rolled up leaves or under bark. Very often the cocoon itself is covered over with a sheet of web. In some families the mother carries it about with her attached to the underside of the abdomen. In other she carries it in her falces until the young are hatched. The cocoons of others, as Uloborus, Argyrodes, etc., while hung out in the web are still concealed by deceptive form and color, or by being covered with rubbish.

Cambridge speaks of A. brunnea, whose cocoons "are covered over very soon after they are made and the eggs deposited in them, with a coating of clay, which effectually destroys all their form and beauty. This coating of clay answers probably two ends: first, the concealment of the cocoon and its protection from

insect enemies; and, secondly, the protection of the eggs from the too powerful rays of the sun, dry clay being (as is well known) one of the best non-conductors of heat."

The peculiar cocoon of C. bisaccata is described by Emerton as follows: "Only one specimen of this (*bisaccata*) was found on a beech tree at New Haven with two cocoons. These were dark brown, as dark as the bark of the tree and as hard. Around the middle of each was a circle of irregular points. One of the cocoons was attached by a strong stem to the bark, and the other was attached in a similar way to the first cocoon. The spider held on to one of the cocoons." In this instance the egg has evidently the same protection as that possessed by the gray, bark-haunting spiders, with the added advantage of hardness.

The habit of distributing the eggs through a number of cocoons made at intervals of several days, is protective. In this way, although one or two of the cocoons may be pierced by the ichneumon, there is a chance that part of the brood may survive.

Indirect Protection. — The indirectly protected group includes those spiders which are rendered inedible by the possession of sharp spines and chitinous plates, and also those that mimic other specially protected creatures.

The females of the specially protected group are characterized by the following attributes:

Their inedibility, which they owe to a more or less coriaceous epidermis and an armature of strong sharp spines (Fig. 6).

Their brilliant colors — glistening black and white,

yellow, fiery gold, metallic silver, rose-color, blue, orange and blood-red.

Their habit of hanging always exposed in the centre of the web.

In an interesting discussion of the protective value of color and marking in insects, Poulton says that "the smaller convergent groups of nauseous insects often present us with ideally perfect types of warning patterns and colors — simple, crude, strongly contrasted — everything subordinated to the paramount necessity of becoming conspicuous," the memory of enemies being thus strongly appealed to.

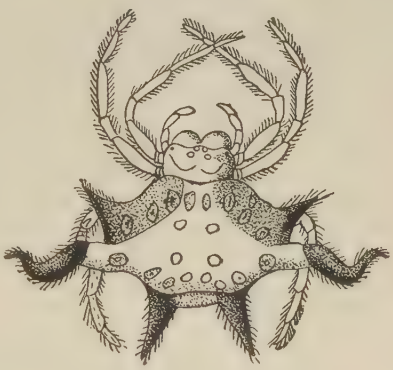


Fig. 6. — Gasteracantha crepidophora (from Cambridge).

This proposition is well illustrated by the Gasteracanthidæ. Among larvæ the warning colors are almost invariably black and white, or black (or some very dark color), in contrast with yellow, orange and red. These are the colors that also constantly recur among the Gasteracanthidæ.

Cases that may be more justly considered exceptions to the rule that these hard, uneatable spiders are conspicuous are such species as Acrosoma rugosa (Fig. 7). One of this species was sent me by Mrs. Treat last summer. It lived for several weeks in my window, making no regular web, but hanging among a few irregular strands. It ate nothing, although provided with insects, but drank greedily of water. It might

seem that its black and white coloring would make it conspicuous, but in connection with its irregular shape and its way of hanging motionless in the web it had the opposite effect.

We have no reason to suppose that the class represented in rugosa is like that touched upon by Poulton, in which very protectively colored larvæ suddenly assume a terrifying aspect on the near approach of an enemy; still they do enjoy a kind of double protection. They are inconspicuous, and thus likely to escape attack, but in case they are attacked they have still the advantage of being quickly rejected. This experience cannot be as fatal to them as to the soft and thin skinned larvæ. Their hard covering and projecting spines would protect them to such an extent as to give them a fair chance of surviving.

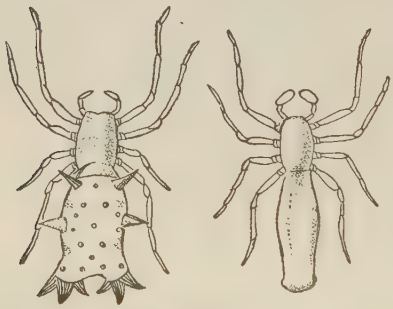


Fig. 7. — Acrosoma Rugosa. Left-hand figure female, right-hand figure male (from Emerton).

In one respect the inconspicuous Gasteracanthidæ have a decided advantage over their bright-colored relatives. The birds, indeed, avoid the conspicuous ones, but their brilliancy serves to attract another enemy against which spines are no protection — the hunter wasp, which, as we have seen in the work of Bates, sometimes provisions its nest wholly with spiders of this family. Mr. Smith gives like testimony, saying:

"Spines on the abdomen of certain spiders would serve as a protection against vertebrate enemies, though

they do not protect against the hunter wasps, which frequently provision their nests with these species." He adds, however, that most of the spiny spiders are common, and that their colors make them conspicuous; just as butterflies that are protected by an odor are common and bright-colored. . . .

Mimicry. — Mimicry, or the imitation of animal forms, while it is a form of indirect protection, differs in no essential respect from the imitation of vegetable and inorganic things. As Bates has said, the object of mimetic tendencies is disguise, and they will work in any direction that answers this purpose.

In nearly all respects spiders come under the three laws given by Wallace, as governing the development of mimetic resemblances in several large classes. These laws are as follows:

1. In an overwhelming majority of cases of mimicry, the animals (or the groups) which resemble each other inhabit the same country, the same district, and in most cases are to be found together on the very same spot.

2. These resemblances are not indiscriminate, but are limited to certain groups, which, in every case, are abundant in species and individuals, and can often be ascertained to have some special protection.

3. The species which resemble or "mimic" these dominant groups, are comparatively less abundant in individuals, and are often very rare.

The second and third of these laws are confirmed by what we know of mimetic resemblances among spiders. They mimic ants much oftener than other creatures, and ants are very abundant, are specially protected, and are much more numerous than the mimetic spiders.

To the first law, also, they conform to a great extent, since everything tends to show that in tropical America and in Africa the ant and the spider, the one mimicked and the other mimicking, are always found together. So far as I can discover, however, the ant-like spiders of North America are not found in company with any species of ant which they resemble. This may be because they do not mimic any particular species, but only the general ant-like form; or, considering that the genera which contain their nearest relatives are much more abundant in Central and South America, it may be that these forms were originally tropical, mimicking some tropical species of ants, and that after the Glacial Epoch they migrated northward, leaving the ants behind them. However this may be, their peculiar form has served them well, since they have maintained themselves as fairly abundant species with a lower fecundity than is found in any other group of spiders.

The cases in which one species mimics another may be divided, according to the kind of benefit derived, into four classes: Class 1. As a rule, where we find one species mimicking another, the mimicked species possesses some special means of defence against the enemies of both. This defence may consist of a disagreeable taste or odor, as in the Heliconidæ, which are mimicked by other butterflies; of some special weapon of offence, as where wasps and bees are mimicked by flies and moths, or poisonous vipers by harmless caterpillars; or of a hard shell, as where the coriaceous beetles are mimicked by those that are soft-bodied.

Instances of this rule are exceedingly numerous; indeed, Wallace says that specially protected forms are

always mimicked; still we have nothing mimicking our Gasteracanthidæ.

Class 2. The mimetic may prey upon the mimicked species, its disguise enabling it to gain a near approach to its victims; as the mantis, mentioned by Bates as exactly resembling the white ants upon which it feeds; and the flies which mimic bees, upon which they are parasitic, and are thus able to enter the nests of the bees and lay eggs on the larvæ.

Class 3. The mimetic species may, by its imitation, be protected from the attacks of the creature it mimics, as is the case with the crickets and grasshoppers which mimic their deadly foe, the hunter wasp.

Class 4. The mimetic species may prey upon some creature which is found commonly with, and is not eaten by, the mimicked species.

No two of these classes are mutually destructive so that in any case of mimicry a double advantage may be gained.

Let us see which of these advantages has directed the development of mimetic tendencies among spiders.

While among beetles and butterflies we most commonly find mimicry of one species by another within the same order, we have no instance of a spider mimicking another spider. This may be accounted for by the fact that the specially protected spiders depend for their safety upon the possession of hard plates and spinous processes, and although the hardened epidermis might be imitated (we know that hard-shelled beetles are mimicked by others that are soft), spines could scarcely be imitated by a soft-bodied creature with sufficient accuracy to insure disguise.

While spiders most commonly mimic ants, we hear also of their imitating beetles, snail-shells, ichneumons and horseflies. There is also a curious Madagascar species which looks exactly like a little scorpion, the resemblance being heightened by its habit of curving its flexible tail up over its back when irritated.

Those that resemble beetles comprise nearly all the species of the genera Coccorchestes and Homalattus. These are small spiders with short, convex bodies. The abdomen fits closely over the cephalothorax, and the epidermis, which has usually a metallic lustre, is sometimes coriaceous. Striking examples are found in H. coccinelloides, which bears a strong resemblance to beetles of the family Coccinelloidæ, and in C. cupreus, in which certain marks on the abdomen imitate the elytra of beetles.

The following account of a spider which mimics a snail-shell is given by Mr. G. F. Atkinson: —

"An undescribed species of *Cyrtarachne* mimics a snail-shell, the inhabitant of which, during the summer and fall, is very abundant on the leaves of plants in this place. In the species of Cyrtarachne the abdomen partly covers the cephalothorax, is very broad at the base, in this species broader than the length of the spider, and rounds off at the apex. When it rests upon the under side of a leaf with its legs retracted it strongly resembles one of these snail-shells by the color and shape of its abdomen. The two specimens which I collected deceived me at first, but a few threads of silk led me to make the examination. The spider seemed so confident of its protection that it would not move when I jarred the plant, striking it several hard blows.

I pulled the spider forcibly from the leaf, and it did not exhibit any signs of movement until transferred to the cyanide bottle." . . .

Trimen gives an account of the imitation, by spiders, of horseflies, a case falling into Class 2, as follows: —

"Hunting spiders are in some cases very like their prey, as may everywhere be noticed in the case of the species of Salticus which catch horseflies on sunny walls and fences. The likeness is not in itself more than a general one of size, form and coloring; but its effect is greatly aided by the actions of the spider, which walks hurriedly for short distances, stopping abruptly, and rapidly moving its falces, in evident mimicry of the well-known movements so characteristic of flies."

Instances of spiders mimicking ants are very numerous, and in many cases the resemblance is so close as to, at first sight, deceive a trained naturalist. This resemblance is brought about by the spider's body being elongated and strongly constricted, so that it appears to be composed of three segments instead of two, by the color, by the way in which the spider moves about, zigzagging from side to side like an ant, and by its habit of holding up one pair of its legs and moving them in such a way that they look exactly like the antennæ of an ant.

Ants may be regarded as specially protected, by their sharp, acid flavor, and in some species by the possession of stings or of horny processes.

On the ground that there are birds which do eat ants, and eat them greedily, it has been thought by some naturalists that they cannot be considered specially protected creatures, and that, as spiders can therefore

derive no protection from mimicking them, all cases of such mimicry depend upon the spider's increased ability to capture the ants as prey, but I am convinced that this is too hasty a conclusion. It is unquestionably true that some birds feed almost exclusively upon ants, but these are the exceptions. It is a common thing to find that specially protected groups, which are safe from the attacks of most creatures, have their special enemies. Thus, even the nauseous Heliconidæ are preyed upon by certain spiders and wasps; and bees, in spite of their stings, are preferred to other insects by the bee-eaters. Moreover, the ant-devouring birds are found largely among the wood-peckers, which eat the ants that run on the trunks of trees, and are therefore not a source of danger to the ant-like spiders, the American species of which, so far as I can learn, live entirely upon the ground.

In the United States comparatively small numbers of either ants or spiders are eaten by birds, but in tropical America there are enormous numbers of humming-birds feeding almost exclusively upon spiders, and there the protective advantage of looking like ants must be of great importance to the smaller species.

Belt considers that the advantages gained by ant-mimicking Central American spiders lies entirely on the side of protection. In relation to this subject he says: "Ant-like spiders have been noticed throughout tropical America and also in Africa. The use that the deceptive resemblance is to them has been explained to be the facility it affords them for approaching ants on which they prey. I am convinced that this explanation is incorrect, so far as the Central American species

are concerned. Ants, and especially the stinging species are, so far as my experience goes, not preyed upon by any other insects. No disguise need be adopted to approach them, as they are so bold that they are more likely to attack a spider than a spider them. Neither have they wings to escape by flying, and generally go in large bodies easily found and approached. The use is, I doubt not, the protection the disguise affords against small insectivorous birds. I have found the crops of some humming-birds full of small, soft-bodied spiders, and many other birds feed on them. Stinging-ants, like bees and wasps, are closely resembled by a host of other insects; indeed, whenever I found any insect provided with special means of defence I looked for imitative forms, and was never disappointed in finding them."

The ant-like species are probably protected by their appearance from the attacks of many of the larger spiders. We have kept great numbers of Attidæ in captivity, and, although they devoured flies, gnats, larvæ, and other spiders, they would never touch ants. Among spiders, however, as among birds, we find that certain groups subsist almost entirely upon ants.

The class of spiders whose mimicry protects them from their enemies, whether they are birds or other spiders, probably includes at least two of our own ant-like species, Synageles picata and Synemosyna formica, which, in confinement, are always hungry for gnats, but will not touch ants, even of small size.

The existence of a class of spiders which mimic the particular species of ants upon which they prey is not to be questioned, but it is doubtful whether the benefit

to the spider is increased facility in capturing the ant, or whether it is merely protective. It may be that the spider, by virtue of its resemblance to the ant, not only gets an abundant supply of food, but also escapes being eaten itself, and thus enjoys a double advantage. Both Bates and Wallace take the ground that the advantage derived by the spider consists in greater ease in the capture of prey, but both of these writers refer to spiders only incidentally to illustrate a general proposition, without special consideration of their peculiar conditions.

Mr. Herbert Smith, who has paid a good deal of attention to this subject, is inclined to believe that the mimicry in question is entirely protective. He writes as follows: —

"In the United States there are a few rare spiders that mimic ants. Here at Taperinha we find a good score of species of these spiders aping the various kinds of ants very closely; even the odd, spiny wood-ant, *cryptocerus*, furnishes a pattern, and there are spiders that mimic the wingless ichneumons. We find, after a while, that the spiders prey upon ants just as our spiders catch flies; indeed, this fact has already been noted by other observers. But we g a step beyond the books when we discover not only that the spiders eat the ants, but that they eat the particular ants which they mimic. At all events, we verify this fact in a great number of cases, and we never find the spiders eating any but the mimicked species. . . . I do not like to hazard a theory on this case of mimicry. It is difficult to suppose that the quick-witted ants would be deceived even by so close a resemblance; and,

in any case, it would seem that the spiders do not require such a disguise in order to capture slow-moving ants. Most birds will not eat ants; it seems likely, therefore, that this is simply another example of protection; the spider deceives its enemies, not its prey; it mimics the particular species that it feeds on, because it is seen in that company when it is hunting, and among a host of similar forms is likely to pass unnoticed."

At first sight, and especially in view of the fact that such cases are not uncommon among insects, it would be naturally supposed that the object of the mimicry was to enable the spider to approach its victim without exciting suspicion; and it is difficult to account, on any other supposition, for the very close resemblance between certain species of spiders and the particular species of ants which they prey upon. It seems as though the highest point of *protective* benefit would have been reached long before the resemblance of the spider to the ant had become so close as it really is. On the other hand, it is difficult to believe that ants are deceived, even by those spiders which mimic them most closely, when we remember that their perceptions are so keen that they discriminate not only between ants of their own and different species, but even between ants of their own species living in two different communities.

The mimicry of ichneumon flies by spiders was noted some years ago by Mr. Herbert Smith. This case comes under Class 3, in which one species mimics another which preys upon it. Great destruction is caused by ichneumons which lay their eggs on the

bodies of the live spiders, and the disguise probably protects the spider by leading the fly to mistake it for one of its own species.

We have no proof that spiders ever mimic ants as a method of escaping from them, but it is possible that this sometimes happens. We know that some ants prey upon them. The foraging ants of South America destroy spiders as well as many kinds of insects, and Wallace mentions a small, wood-boring ant which fills its nest with small spiders.

If the spiders that feed upon ants deceive them by their mimicry those which are preyed upon by ants would gain an advantage by a similar disguise. I once placed a little ant-like spider of the genus Herpyllus in a bottle with three ants no larger than itself, which I had caught with it in the sweep-net. In a very few minutes the ants had killed and begun to devour the spider. It may be that the resemblance was sufficiently close to deceive them in the open, but failed when spider and ants were confined together in close quarters.

THE BATH OF THE BIRDS

By RICHARD JEFFERIES.

ONE morning Sir Bevis went down to the brook. Standing on the brink, he said: "Brook, Brook! what are you singing? You promised to tell me what you were saying."

The brook did not answer, but went on singing. Bevis listened a minute, and then he picked a willow leaf and threw it into the bubbles and watched it go whirling round and round in the eddies and back up under the fall, where it dived down and presently came up again, and the stream took it and carried it away past the flags. "Brook, Brook!" said Bevis, stamping his foot; "tell me what you are singing."

And the brook, having now finished that part of his song, said: "Bevis, dear; sit down in the shadow of the willow, for it is very hot to-day, and the reapers are at work; sit down under the willow and I will tell you as much as I can remember."

"But the reed said you could not remember anything," said Bevis, leaning back against the willow.

"The reed did not tell you the truth, dear; indeed, he does not know all; the fact is, the reeds are so fond of talking that I scarcely ever answer them now or they

would keep on all day long, and I should never hear the sound of my own voice, which I like best. So I do not encourage them, and that is why the reeds think I do not recollect."

"And what is that you sing about?" said Bevis impatiently.

"My darling," said the brook, "I do not know myself always what I am singing about. I am so happy I sing, sing, and never think about what it means; it does not matter what you mean as long as you sing. Sometimes I sing about the sun, who loves me dearly, and tries all day to get at me through the leaves and the green flags that hide me; he sparkles on me everywhere he can, and does not like me to be in the shadow. Sometimes I sing to the wind, who loves me next most dearly, and will come to me everywhere in places where the sun cannot get. He plays with me whenever he can, and strokes me softly and tells me the things he has heard in the woods and on the hills, and sends down the leaves to float along; for he knows I like something to carry. Fling me in some leaves, Bevis, dear.

"Sometimes I sing to the earth and the grass; they are fond of me, too, and listen the best of all. I sing loudest at night to the stars; for they are so far away they would not otherwise hear me."

"But what do you say?" said Bevis; but the brook was too occupied now to heed him and went on.

"Sometimes I sing to the trees; they, too, are fond of me and come as near as they can; they would all come down close to me if they could. They love me like the rest, because I am so happy and never cease

my chanting. If I am broken to pieces against a stone, I do not mind in the least; I laugh just the same and even louder. When I come over the hatch, I dash myself to fragments; and sometimes a rainbow comes and stays a little while with me. The trees drink me, and the grass drinks me; the birds come down and drink me; they splash me and are happy. The fishes swim about, and some of them hide in deep corners. Round the bend I go; and the osiers say they never have enough of me. The long grass waves and welcomes me; the moor-hens float with me; the kingfisher is always with me somewhere, and sits on the bough to see his ruddy breast in the water. And you come too, Bevis, now and then to listen to me; and it is all because I am so happy."

"Why are you so happy?" said Bevis.

"I do not know," said the brook. "Perhaps it is because all I think of is this minute; I do not know anything about the minute just gone by, and I do not care one bit about the minute that is just coming; all I care about is this minute, this very minute now. Fling me in some more leaves, Bevis. Why do you go about asking questions, dear? Why don't you sing and do nothing else?"

"Oh, but I want to know all about everything," said Bevis. "Where did you come from, and where are you going, and why don't you go on and let the ground be dry — why don't you run on, and run all away? why are you always here?"

The brook laughed and said: "My dear, I do not know where I came from, and I do not care at all where I am going. What does it matter, my love? All I know is

I shall come back again; yes, I shall come back again." The brook sang very low and rather sadly now: "I shall go into the sea and shall be lost; and even you would not know me; ask your father, love; he has sailed over the sea in ships that come to Southampton, and I was close to him, but he did not know me. But by and by, when I am in the sea, the sun will lift me up, and the clouds will float along — look towards the hills, Bevis, dear, every morning and you will see the clouds coming and bringing me with them; and the rain and the dew, and sometimes the thunder and the lightning, will put me down again; and I shall run along here and sing to you, my sweet, if you will come and listen. Fling in some little twigs, my dear, and some bits of bark from the tree."

"That I will," said Bevis; and he picked up a stone and flung it into the water with such a splash that the kingfisher flew away; but the brook only laughed and told him to throw another and to make haste and grow bigger and jump over him.

"S—s, we shall meet by the drinking place," said the grasshopper; and was just hopping off, when Bevis asked him what the birds went down to bathe for.

"I'm sure I do not know," said the grasshopper, speaking fast, for he was rather in a hurry to be gone; he never could stand still long together. "All I can tell you is, that on Midsummer Day every one of the birds has to go down to the brook and walk in and bathe; and it has been the law for so many, many years that no one can remember when it began. They like it very much, because they can show off their fine

feathers which are just now in full color; and if you like to go with me, you will be sure to enjoy it."

"So I will," said Bevis; and he followed the grasshopper, who hopped so far at every step that he had to walk fast to keep up with him.

They went on in silence a good way, except that the grasshopper cried "S—s" to his friends in the grass as he passed, and said good-morning also to a mole, who peeped out for a moment.

"Why don't you hop straight?" said Bevis presently. "It seems to me that you hop first one side and then the other, and go in such a zigzag fashion it will take us hours to reach the brook."

"How very stupid you are!" said the grasshopper. "If you go straight, of course you can only see just what is under your feet; but if you go first this way and then that, then you see everything. You are nearly as silly as the ants, who never see anything beautiful all their lives. Be sure you have nothing to do with the ants, Bevis; they are a mean, wretched, miserly set, quite contemptible and beneath notice. Now, I go everywhere, all round the field, and spend my time searching for lovely things; sometimes I find flowers, and sometimes the butterflies come down into the grass and tell me the news; and I am so fond of the sunshine, I sing to it all day long. Tell me, now, is there anything so beautiful as the sunshine and the blue sky, and the green grass, and the velvet and blue and spotted butterflies, and the trees which cast such a pleasant shadow and talk so sweetly, and the brook which is always running? I should like to listen to it for a thousand years."

"I like you," said Bevis; "jump into my hand and I will carry you." He held his hand out flat, and in a second up sprang the grasshopper and alighted on his palm and told him the way to go, and thus they went together merrily.

"Bevis, dear, I do not sing at night; but I always go where I can see a star. I slept under a mushroom last night, and he told me he was pushing up as fast as he could before some one came and picked him to put on a gridiron. I do not lay up any store, because I know I shall die when the summer ends; and what is the use of wealth then? My store and my wealth is the sunshine, dear, and the blue sky, and the green grass, and the delicious brook who never ceases sing, sing, singing all day and night. And all the things are fond of me; the grass and the flowers, and the birds and the animals — all of them love me."

"I think I shall take you home and put you under a glass case on the mantelpiece," said Bevis.

Off jumped the grasshopper in a moment, and fell so lightly on the grass it did not hurt him in the least, though it was as far as if Bevis had tumbled down out of the clouds. Bevis tried to catch him, but he jumped so nimbly this way and that, and hopped to and fro, and lay down in the grass, that his green coat could not be seen. Bevis now went down to the brook and stood on the bank, where it was high, near a bush at the side of the drinking place. "Ah, dear little Sir Bevis!" whispered a reed, bending towards him as the wind blew, "please do not come any nearer; the bank is steep and treacherous, and hollow underneath where the water-rats run. So do not lean over after the

forget-me-nots — they are too far for you. Sit down where you are, behind that little bush, and I will tell you all about the bathing. The birds come down to bathe every Midsummer Day, and the goldfinches, and the sparrows, and the blackbirds, and the thrushes, and the swallows, and the wrens, and the robins, and almost every one of them, except two or three, whose great-grandfathers got into disgrace a long while ago. The rooks do not come because they are thieves, and steal the mussels, nor the crows, who are a very bad lot; the swan does not come either, unless the brook is muddy after a storm. The swan is so tired of seeing himself in the water that he quite hates it, and that is the reason he holds his neck so high, that he may not see more of himself than he can help."

Soon the birds came. They were all in their very best and brightest feathers, and as the sun shone on them and they splashed the water and strutted about, Bevis thought he had never seen anything so beautiful.

They did not all bathe, for some of them were specially permitted only to drink instead, but they all came, and all in their newest dresses. So bright was the goldfinch's wing, that the lark, though she did not dare speak, had no doubt she rouged. The sparrow, brushed and neat, so quiet and subdued in his brown velvet, looked quite aristocratic among so much flaunting color. As for the blackbird he had carefully washed himself in the spring before he came to bathe in the brook, and he glanced round with a bold and defiant air, as much as to say: "There is not one of you who has so yellow a bill, and so beautiful a black coat as I

have." In the bush the bullfinch, who did not care much to mix with the crowd, moved restlessly to and fro. The robin looked all the time at Bevis, so anxious was he for admiration. The wood-pigeon, very consequential, affected not to see the dove, whom Bevis longed to stroke, but could not, as he had promised the reed to keep still.

Bevis looked up into the sky, and there was the hawk, almost up among the white clouds, soaring round and round, and watching all that was proceeding. Almost before he could look down again a shadow went by, and a cuckoo flew along very low, just over the drinking place.

"Cuckoo!" he cried, "cuckoo! The goldfinch has the prettiest dress;" and off he went.

Now the hawk had bribed the cuckoo, who was his cousin, to do this, and the cuckoo was not at all unwilling, for he had an interest himself in keeping the birds divided, so he said that although he had made up his mind to go on his summer tour, leaving his children to be taken care of by the wagtail, he would stop a day or two longer to manage this little business. No sooner had the cuckoo said this, than there was a most terrible uproar, and all the birds cried out at once. The blackbird was so disgusted that he flew straight off, chattering all across the field and up the hedge. The bullfinch tossed his head, and asked the goldfinch to come up in the bush and see which was stronger. The greenfinch and the chaffinch shrieked with derision; the wood-pigeon turned his back and said "Pooh!" and went off with a clatter. The sparrow flew to tell his mates on the house, and you could hear the chatter they made

about it right down at the brook. But the wren screamed loudest of all, and said that the goldfinch was a painted impostor, and had not got half so much gold as the yellow-hammer. So they were all scattered in a minute, and Bevis stood up and hurried homeward.

THE LOON

(From Walden.)

By HENRY D. THOREAU.

IT is remarkable how many creatures live wild and free, though secret, in the woods, and still sustain themselves in the neighborhood of towns, suspected by hunters only. How retired the otter manages to live here! He grows to be four feet long, as big as a small boy, perhaps without any human being getting a glimpse of him. I formerly saw the raccoon in the woods behind where my house is built, and probably still heard their whinnering at night. Commonly I rested an hour or two in the shade at noon, after planting, and ate my lunch, and read a little by a spring which was the source of a swamp and of a brook, oozing from under Brister's Hill, half a mile from my field. The approach to this was through a succession of descending grassy hollows, full of young pitch-pines, into a larger wood about the swamp.

There, in a very secluded and shaded spot, under a spreading white-pine, there was yet a clean, firm sward to sit on. I had dug out the spring and made a well of clear gray water, where I could dip up a pailful without roiling it, and thither I went for this purpose almost every day in midsummer, when the pond was

warmest. Thither, too, the wood-cock led her brood, to probe the mud for worms, flying but a foot above them down the bank, while they ran in a troop beneath; but at last, spying me, she would leave her young and circle round and round me, nearer and nearer till within four or five feet, pretending broken wings and legs, to attract my attention, and get off her young, who would already have taken up their march, with faint wiry peep, single file through the swamp, as she directed. Or I heard the peep of the young when I could not see the parent bird.

There, too, the turtle-doves sat over the spring, or fluttered from bough to bough of the soft white-pines over my head; or the red squirrel, coursing down the nearest bough, was particularly familiar and inquisitive. You only need sit still long enough in some attractive spot in the woods that all its inhabitants may exhibit themselves to you by turns. . . .

In the fall the loon (*Colymbus glacialis*) came, as usual, to moult and bathe in the pond, making the woods ring with his wild laughter before I had risen. At rumor of his arrival all the Mill-dam sportsmen are on the alert, in gigs and on foot, two by two and three by three, with patent rifles and conical balls and spy-glasses. They come rustling through the woods like autumn leaves, at least ten men to one loon. Some station themselves on this side of the pond, some on that, for the poor bird cannot be omnipresent; if he dive here he must come up there.

But now the kind October wind rises, rustling the leaves and rippling the surface of the water, so that no loon can be heard or seen, though his foes sweep the

pond with spy-glasses, and make the woods resound with their discharges. The waves generously rise and dash angrily, taking sides with all waterfowl, and our sportsmen must beat a retreat to town and shop and unfinished jobs. But they were too often successful. When I went to get a pail of water early in the morning I frequently saw this stately bird sailing out of my cove within a few rods. If I endeavored to overtake him in a boat, in order to see how he would manœuvre, he would dive and be completely lost, so that I did not discover him again, sometimes, till the latter part of the day. But I was more than a match for him on the surface. He commonly went off in a rain.

As I was paddling along the north shore one very calm October afternoon, for such days especially they settle on to the lakes, like the milkweed down, having looked in vain over the pond for a loon, suddenly one, sailing out from the shore toward the middle a few rods in front of me, set up his wild laugh and betrayed himself. I pursued with a paddle and he dived, but when he came up I was nearer than before. He dived again but I miscalculated the direction he would take, and we were fifty rods apart when he came to the surface this time, for I had helped to widen the interval; and again he laughed long and loud, and with more reason than before.

He manœuvred so cunningly that I could not get within half a dozen rods of him. Each time when he came to the surface, turning his head this way and that, he coolly surveyed the water and the land, and apparently chose his course so that he might come up where there was the widest expanse of water and at the greatest

distance from the boat. It was surprising how quickly he made up his mind and put his resolve into execution. He led me at once to the wildest part of the pond, and could not be driven from it. While he was thinking one thing in his brain, I was endeavoring to divine his thought in mine. It was a pretty game, played on the smooth surface of the pond, a man against a loon.

Suddenly your adversary's checker disappears beneath the board, and the problem is to place yours nearest to where his will appear again. Sometimes he would come up unexpectedly on the opposite side of me, having apparently passed directly under the boat. So long-winded was he and so unweariable, that when he had swam farthest he would immediately plunge again, nevertheless; and then no wit could divine where in the deep pond, beneath the smooth surface, he might be speeding his way like a fish, for he had time and ability to visit the bottom of the pond in its deepest part. It is said that loons have been caught in the New York lakes eighty feet beneath the surface, with hooks set for trout, — though Walden is deeper than that. How surprised must the fishes be to see this ungainly visitor from another sphere speeding his way amid their schools!

Yet he appeared to know his course as surely under water as on the surface, and swam much faster there. Once or twice I saw a ripple where he approached the surface, just put his head out to reconnoitre, and instantly dived again. I found that it was as well for me to rest on my oars and wait his reappearing as to endeavor to calculate where he would rise; for again and again, when I was straining my eyes over the

surface one way, I would suddenly be startled by his unearthly laugh behind me. But why, after displaying so much cunning, did he invariably betray himself the moment he came up by that loud laugh? Did not his white breast enough betray him?

He was indeed a silly loon, I thought. I could commonly hear the plash of the water when he came up, and so also detected him. But after an hour he seemed as fresh as ever, dived as willingly and swam yet farther than at first. It was surprising to see how serenely he sailed off with unruffled breast when he came to the surface, doing all the work with his webbed feet beneath. His usual note was this demoniac laughter, yet somewhat like that of a waterfowl; but occasionally when he had balked me most successfully and come up a long way off, he uttered a long-drawn unearthly howl, probably more like that of a wolf than any bird; as when a beast puts his muzzle to the ground and deliberately howls. This was his looning, — perhaps the wildest sound that is ever heard here, making the woods ring far and wide. I concluded that he laughed in derision of my efforts, confident of his own resources.

Though the sky was by this time overcast, the pond was so smooth that I could see where he broke the surface when I did not hear him. His white breast, the stillness of the air, and the smoothness of the water were all against him. At length, having come up fifty rods off, he uttered one of those prolonged howls, as if calling on the god of loons to aid him, and immediately there came a wind from the east and rippled the surface, and filled the whole air with misty rain, and I was impressed as if it were the prayer of the loon

answered, and his god was angry with me; and so I left him disappearing far away on the tumultuous surface.

For hours, in fall days, I watched the ducks cunningly tack and veer and hold the middle of the pond, far from the sportsman; tricks which they will have less need to practise in Louisiana bayous. When compelled to rise they would sometimes circle round and round and over the pond at a considerable height, from which they could easily see to other ponds and the river, like black motes in the sky; and, when I thought they had gone off thither long since, they would settle down by a slanting flight of a quarter of a mile on to a distant part which was left free; but what beside safety they got by sailing in the middle of Walden I do not know, unless they love its water for the same reason that I do.

THE DARTMOOR PONIES, OR THE WANDERINGS OF THE HORSE TRIBE

(From "Through Magic Glasses.")

By ARABELLA B. BUCKLEY.

I WANT you to take a journey with me which I took in imagination a few days ago, as I lay on my back on the sunny moor and watched the Dartmoor ponies.

It was a calm misty morning one day last week, giving promise of a bright and sunny day, when I started off for a long walk across the moor to visit the famous stone-circles, many of which are to be found not far off the track, called Abbot's Way, leading from Buckfast Abbey, on the Dart, to the Abbey of Tavistock, on the Tavy.

My mind was full of the olden times as I pictured to myself how, seven hundred years or more ago, some Benedictine monk from Tavistock Abbey, in his black robe and cowl, paced this narrow path on his way to his Cistercian brethren at Buckfast, meeting some of them on his road as they wandered over the desolate

moor in their white robes and black scapularies in search of stray sheep. For the Cistercians were shepherds and wool-weavers, while the Benedictines devoted themselves to learning, and the track of about twenty-five miles from one abbey to the other, which still remains, was worn by the members of the two communities and their dependents, the only variety in whose lives consisted probably in these occasional visits one to the other.

Yet even these monks belonged to modern times compared to the ancient Britons who raised the stone-circles, and buried their dead in the barrows scattered here and there over the moor; and my mind drifted back to the days when, long before that pathway was worn, men clad in the skins of beasts hunted wild animals over the ground on which I was treading, and lived in caves and holes of the ground.

I wondered, as I thought of them, whether the cultured monks and the uncivilized Britons delighted as much in the rugged scenery of the moor as I did that morning. For many miles in front of me the moor stretched out wild and treeless; the sun was shining brightly upon the mass of yellow furze and deep-red heather, drawing up the moisture from the ground, and causing a kind of watery haze to shimmer over the landscape; while the early mist was rising off the *tors*, or hill-tops, in the distance, curling in fanciful wreaths around the rugged and stony summits, as it dispersed gradually in the increasing heat of the day.

The cattle which were scattered in groups here and there feeding on the dewy grass were enjoying the happiest time of the year. The moor, which in winter affords

them scarcely a bare subsistence, is now richly covered with fresh young grass, and the sturdy oxen fed solemnly and deliberately, while the wild Dartmoor ponies and their colts scampered joyously along, shaking their manes and long flowing tails, and neighing to each other as they went; or clustered together on some verdant spot, where the colts teased and bit each other for fun, as they gambolled round their mothers.

It was a pleasure, there on the open moor, with the lark soaring overhead, and the butterflies and bees hovering among the sweet-smelling furze blossoms, to see horses free and joyous, with no thought of bit or bridle, harness or saddle, whose hoofs had never been handled by the shoeing-smith, nor their coats touched with the singeing iron. Those little colts, with their thick heads, shaggy coats, and flowing tails, will have at least two years more freedom before they know what it is to be driven or beaten. Only once a year are they gathered together, claimed by their owners and branded with an initial, and then left again to wander where they will. True, it is a freedom which sometimes has its drawbacks, for if the winter is severe the only food they can get will be the furze-tops, off which they scrape the snow with their feet; yet it is very precious in itself, for they can gallop when and where they choose, with head erect, sniffing at the wind and crying to each other for the very joy of life.

Now as I strolled across the moor and watched their gambols, thinking how like free wild animals they seemed, my thoughts roamed far away, and I saw in imagination scenes where other untamed animals of the horse tribe are living unfettered all their lives long.

First there rose before my mind the level grass-covered pampas of South America, where wild horses share the boundless plains with troops of the rhea, or American ostrich, and wander, each horse with as many mares as he can collect, in companies of hundreds or even thousands in a troop. These horses are now truly wild, and live freely from youth to age, unless they are unfortunate enough to be caught in the more inhabited regions by the lasso of the hunter. In the broad pampas, the home of herds of wild cattle, they dread nothing. There, as they roam with one bold stallion as their leader, even beasts of prey hesitate to approach them, for, when they form into a dense mass with the mothers and young in their centre, their heels deal blows which even the fierce jaguar does not care to encounter, and they trample their enemy to death in a very short time. Yet these are not the original wild horses we are seeking, they are the descendants of tame animals, brought from Europe by the Spaniards to Buenos Ayres in 1535, whose descendants have regained their freedom on the boundless pampas and prairies.

As I was picturing them careering over the plains, another scene presented itself and took their place. Now I no longer saw around me tall pampas-grass with the long necks of the rheas appearing above it, for I was on the edge of a dreary, scantily covered plain between the Aral Sea and the Balkash Lake in Tartary. To the south lies a barren sandy desert, to the north the fertile plains of the Kirghiz steppes, where the Tartar feeds his flocks, and herds of antelopes gallop over the fresh green pasture; and between

these is a kind of no-man's land, where low scanty shrubs and stunted grass seem to promise but a poor feeding-ground.

Yet here the small long-legged but powerful "Tarpans," the wild horses of the treeless plains of Russia and Tartary, were picking their morning meal. Sturdy wicked little fellows they are, with their shaggy light-brown coats, short wiry manes, erect ears, and fiery watchful eyes. They might well be supposed to be true wild horses, whose ancestors had never been tamed by man; and yet it is more probable that even they escaped in early times from the Tartars, and have held their own ever since, over the grassy steppes of Russia and on the confines of the plains of Tartary. Sometimes they live almost alone, especially on the barren wastes where they have been seen in winter, scraping the snow off the herbage as our ponies do on Dartmoor. At other times, as in the south of Russia, where they wander between the Dnieper and the Don, they gather in vast herds and live a free life, not fearing even the wolves, which they beat to the ground with their hoofs. From one green oasis to another they travel over miles of ground.

"A thousand horse — and none to ride!
With flowing tail, and flying mane,
Wide nostrils — never stretched by pain,
Mouths bloodless to the bit or rein,
And feet that iron never shod,
And flanks unscarred by spur or rod,
A thousand horse, the wild, the free,
Like waves that follow o'er the sea."[1]

[1] Byron's *Mazeppa*.

As I followed them in their course I fancied I saw troops of yet another animal of the horse tribe, the "Kulan," or *Equus hemionus*, which is a kind of half horse, half ass (p. 393), living on the Kirghiz steppes of Tartary and spreading far beyond the range of the Tarpan into Tibet. Here at last we have a truly wild animal, never probably brought into subjection by man. The number of names he possesses shows how widely he has spread. The Tartars call him "Kulan," the Tibetans "Kiang," while the Mongolians give him the unpronounceable name of "Dschiggetai." He will not submit to any of them, but if caught and confined soon breaks away again to his old life, a "free and fetterless creature."

No one has ever yet settled the question whether he is a horse or an ass, probably because he represents an animal truly between the two. His head is graceful, his body light, his legs slender and fleet, yet his ears are long and ass-like; he has narrow hoofs, and a tail with a tuft at the end like all the ass tribe; his color is a yellow brown, and he has a short dark mane and a long dark stripe down his back as a donkey has, though this last character you may also see in many of our Devonshire ponies. Living often on the high plateaux, sometimes as much as fifteen hundred feet above the sea, this "child of the steppes" travels in large companies even as far as the rich meadows of Central Asia; in summer wandering in green pastures, and in winter seeking the hunger-steppes where sturdy plants grow. And when autumn comes the young steeds go off alone to the mountain heights to survey the country around and call wildly for mates, whom, when

found, they will keep close to them through all the next year, even though they mingle with thousands of others.

Till about ten years ago the *Equus hemionus* was the only truly wild horse known, but in the winter of 1879–80 the Russian traveller Przevalsky brought back from Central Asia a much more horse-like animal, called by the Tartars "Kertag" and by the Mongols "Statur." It is a clumsy, thick-set, whitish-gray creature with strong legs and a large, heavy, reddish-colored head; its legs have a red tint down to the knees, beyond which they are blackish down to the hoofs. But the ears are small, and it has the broad hoofs of the true horse, and warts on his hind legs, which no animal of the ass tribe has. This horse, like the Kiang, travels in small troops of from five to fifteen, led through the wildest parts of the Dsungarian desert, between the Altai and Tianschan Mountains, by an old stallion. They are extremely shy, and see, hear, and smell very quickly, so that they are off like lightning whenever anything approaches them.

So having travelled over America, Europe, and Asia, was my quest ended? No; for from the dreary Asiatic deserts my thoughts wandered to a far warmer and more fertile land, where between the Blue Nile and the Red Sea rise the lofty highlands of Abyssinia, among which the African wild ass (*Asinus tæniopus*), the probable ancestor of our donkeys, feeds in troops on the rich grasses of the slopes, and then onwards to the bank of a river in Central Africa where on the edge of a forest, with rich pastures beyond, elephants and rhinoceroses, antelopes and buffaloes, lions and

hyænas, creep down in the cool of the evening to slake their thirst in the flowing stream. There I saw the herds of Zebras in all their striped beauty coming down from the mountain regions to the north, and mingling with the darker-colored but graceful quaggas from the southern plains, and I half-grieved at the thought how these untamed and free rovers are being slowly but surely surrounded by man closing in upon them on every side.

I might now have travelled still farther in search of the Onager, or wild ass of the Asiatic and Indian deserts, but at this point a more interesting and far wider question presented itself, as I flung myself down on the moor to ponder over the early history of all these tribes.

Where have they all come from? Where shall we look for the first ancestors of these wild and graceful animals? For the answer to this question I had to travel back to America, to those Western United States where Professor Marsh has made such grand discoveries in horse history. For there, in the very country where horses were supposed never to have been before the Spaniards brought them a few centuries ago, we have now found the true birthplace of the equine race.

Come back with me to a time so remote that we cannot measure it even by hundred of thousands of years, and let us visit the territories of Utah and Wyoming. Those highlands were very different then from what they are now. Just risen out of the seas of the Cretaceous Period, they were then clothed with dense forests of palms, tree-ferns, and screw-pines, magnolias

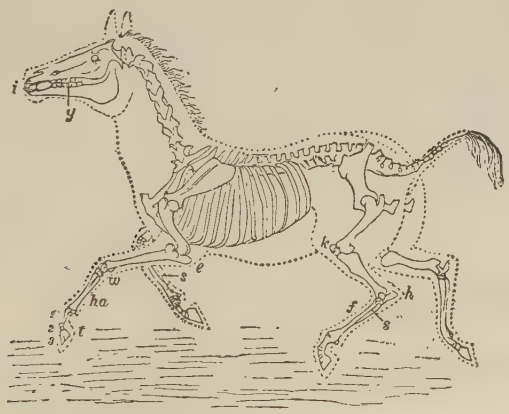
and laurels, interspersed with wide-spreading lakes, on the margins of which strange and curious animals fed and flourished. There were large beasts with teeth like the tapir and the bear, and feet like the elephant; and others far more dangerous, half bear, half hyæna, prowling around to attack the clumsy paleotherium or the anoplotherium, something between a rhinoceros and a horse, which grazed by the waterside, while graceful antelopes fed on the rich grass. And among these were some little animals no bigger than foxes, with four toes and a splint for the fifth, on their front feet, and three toes on the hind ones.

These clumsy little animals, whose bones have been found in the rocks of Utah and Wyoming, have been called *Eohippus*, or horses of the dawn, by naturalists. They were animals with real toes, yet their bones and teeth show that they belonged to the horse tribe, and already the fifth toe common to most other toed animals was beginning to disappear.

This was in the Eocene Period, and before it passed away with its screw-pines and tree-ferns, another rather larger animal, called the Orohippus, had taken the place of the small one, and he had only four toes on his front feet. The splint had disappeared, and as time went on still other animals followed, always with fewer toes, while they gained slender fleet legs, together with an increase in size and in gracefulness. First one as large as a sheep (Mesohippus) had only three toes and a splint. Then the splint again disappeared, and one large and two dwindling toes only remained, till finally these two became mere splints, leaving one large toe or hoof with almost imperceptible

splints, which may be seen on the fetlock of a horse's skeleton.

You must notice that a horse's foot really begins at the point which we call his knee in the front legs, and at his hock in his hind legs. His true knee and elbow are close up to the body. What we call his foot or hoof is really the end of the strong, broad, middle toe



Skeleton of Horse or Ass.

i, Incisor teeth. *g*, Grinding teeth, with the gap between the two as in all grass-feeders. *k*, Knee. *h*, Hock or heel. *f*, Foot. *s*, Splints or remains of the two lost toes. *e*, Elbow. *w*, Wrist. *h*, Hand-bone. *t*, Middle toe of three joints, 1, 2, 3 forming the hoof.

covered with a hoof, and farther up his foot we can feel two small splints, which are remains of two other toes.

Meanwhile during these long succeeding ages while the foot was lengthening out into a slender limb the animals became larger, more powerful, and more swift, the neck and head became longer and more graceful, the brain-case larger in front and the teeth decreased in number, so that there is now a large gap between the

biting teeth and the grinding teeth of a horse. Their slender limbs too became more flexible and fit for running and galloping, till we find the whole skeleton the same in shape, though not in size, as in our own horses and asses now.

They did not, however, during all this time remain confined to America, for, from the time when they arrived at an animal called *Miohippus*, or lesser horse, which came after the Mesohippus and had only three toes on each foot, we find their remains in Europe, where they lived in company with the giraffes, opossums, and monkeys which roamed over these parts in those ancient times. Then a little later we find them in Africa and India; so that the horse tribe, represented by creatures about as large as donkeys, had spread far and wide over the world.

And now, curiously enough, they began to forsake, or to die out in, the land of their birth. Why they did so we do not know; but while in the old world as asses, quaggas, and zebras, and probably horses, they flourished in Asia, Europe, and Africa, they certainly died out in America, so that ages afterwards, when that land was discovered, no animal of the horse tribe was found in it.

And the true horse, where did he arise? Born and bred probably in Central Asia from some animal like the "Kulan," or the "Kertag," he proved too useful to savage tribes to be allowed his freedom, and it is doubtful whether in any part of the world he escaped subjection. In our own country he probably roamed as a wild animal till the savages, who fed upon him, learned in time to put him to work; and when the

Romans came they found the Britons with fine and well-trained horses.

Yet though tamed and made to know his master, he has, as we have seen, broken loose again in almost all parts of the world — in America on the prairies and pampas, in Europe and Asia on the steppes, and in Australia in the bush. And even in Great Britain, where so few patches of uncultivated land still remain, the young colts of Dartmoor, Exmoor, and Shetland, though born of domesticated mothers, seem to assert their descent from wild and free ancestors as they throw out their heels and toss up their heads with a shrill neigh, and fly against the wind with streaming manes and outstretched tails as the Kulan, the Tarpan, and the Zebra do in the wild desert or grassy plain.

NOTES

ALLEN, GRANT, English scientist and man of letters; born 1848, died 1899. Was born in Canada, and passed his boyhood there. Educated in France and at Oxford University. He wrote "Physiological Æsthetics," "Vignettes from Nature," "The Evolutionist at Large," "Force and Energy," many scientific papers in periodicals, and some fiction. "Strange Stories," "The Reverend John Creedy," "Philistia," "The British Barbarians" among others.

BELT, T. G., an English traveller of the nineteenth century, best known by his book, "The Naturalist in Nicaragua."

BLATCHLEY, W. S., American naturalist and geologist, born 1859. Has taken part in many important geological surveys, and is State geologist of Indiana. Among his writings are "Gleanings from Nature," and many important highly technical contributions to State scientific publications.

BRUNER, L., American professor of entomology and ornithology at the University of Nebraska, born 1856. Is the State entomologist of Nebraska. Has written "An Introduction to the Study of Entomology," and some papers on the locusts of Argentina, as well as many technical scientific reports in State papers, etc.

BURROUGHS, JOHN, American essayist, born 1837. Has written much on nature observation. Among his books are "Wake Robin," "Winter Sunshine," "Birds and Poets," "Pepacton," "Fresh Fields," "Signs and Seasons," etc. He was at first a school teacher, then a clerk of the treasury, then a national bank examiner, and he now lives on a farm, devoting himself to literature and fruit culture.

HOPLEY, MRS. C. C., an English author who lived much in America, and made a special study of "Snakes," on which subject she wrote a great deal. Her book entitled "Snakes" is the most important record of her work.

HUXLEY, T. H. Famous English biologist, born 1825; died 1895. Was assistant surgeon in the navy, then professor of natural history, rector of Aberdeen University, and president of the Royal Society. Among his books are, "Evidences as to Man's Place in Nature," "Comparative Anatomy," "Lay Sermons," "Critiques and Addresses," "Physiography," "The Crayfish," "Science and Culture," "Evolution and Ethics," "The Anatomy of Invertebrate Animals," etc.

JEFFERIES, RICHARD, born near Swindon, Wiltshire, Nov. 6, 1848; died Aug. 14, 1887. A naturalist whose fascinating writings were recognized as classics only after his death. Among his most popular books are, "The Gamekeeper at Home" (1878), "Wild Life in a Southern Country" (1879), "The Amateur Poacher" (1880), "Round About a Great Estate" (1881), "Nature Near London," and "The Story of My Heart" (1883), "Red Deer" (1884), and "The Open Air" (1885).

JORDAN, DAVID STARR, President Leland Stanford, Jr., University; born Gainesville, N.Y., Jan. 19, 1851; graduated Cornell M. S., 1872; M. D. Indiana Medical College, 1875; (Ph.D. Butler University, 1878; LL.D. Cornell University, 1886). Held chairs in various collegiate institutions, 1872-79; assistant to U. S. Fish Commission, 1877-91; professor of zoölogy 1879-85, and president 1885-91, Indiana Uni-

versity; president Leland Stanford Jr., University since 1891; president California Academy of Sciences 1896–98; also U. S. Commissioner in charge of fur-seal investigations, etc. Author: "A Manual of Vertebrate Animals of Northern United States," "Science Sketches," "Fishes of North and Middle America" (4 vols.); "Footnotes to Evolution," "Matka and Kotik," "Care and Culture of Men," "The Innumerable Company," "Imperial Democracy," "Animal Life," "Animal Forms," "The Strength of Being Clean," "Standeth God within the Shadow," also numerous papers on Ichthyology, in procedures of various societies and government bureaus.

MAETERLINK, MAURICE, Belgian dramatist and poet, born 1864. He began early to write plays, which were translated into English and represented in London. He has written "Le Trésor des Humbles," "Aglavaine and Selysette," "Pélléas and Melisande." "The Intruder," "Princess Maleine," "Wisdom and Destiny." He has been called the "Belgian Shakespeare."

MORLEY, MARGARET W., author and teacher, born 1858. Has taught in New York State and in the West. She is the author of "A Song of Life," "Life and Love," "A Few Familiar Flowers," "Flowers and their Friends," "The Bee People," "The Honey Makers," "Seed Babies," "Little Wanderers," "Wasps and their Ways," etc.

THOREAU, HENRY DAVID, born at Concord, Mass., July 12, 1817; died May 6, 1862. After his graduation from Harvard, in 1837, he helped his father make lead pencils. In 1839 he began his careful studies on nature, and made a voyage on the Concord and Merrimac Rivers described in his first book. His most popular work, "Walden, or Life in the Woods," was published in 1854. After his death several volumes were made up from his voluminous diaries. His collected writings, in ten volumes, were published in 1893.

WALLACE, A. R., noted English naturalist and traveller, born 1822. Was educated as a land surveyor, but turned his attention exclusively to natural history. He explored the valleys of the Amazon and Rio Negro, travelled in the Malay Archipelago and Papua. He and Darwin both announced together the theory of natural selection. He wrote "Travels on the Amazon," "Palm Trees of the Amazon," "The Malay Archipelago," "Contributions to the Theory of Natural Selection," "Geographical Distribution of Animals," Tropical Nature," "Island Life," etc.

WILSON, A., English physiologist, lecturer, and journalist, born 1852. Educated Edinburgh University and Medical School. Has written much on popular physiology in the newspapers and magazines. Is the author of "Studies on Life, "Leisure Time Studies," "Science Stories," "Chapters on Evolution," "Leaves from a Naturalist's Note Book," "Wild Animals," "Elements of Zoölogy," etc

NATURAL HISTORY

SUGGESTIONS FOR SUPPLEMENTARY READINGS

Days Out of Doors
Charles C. Abbott

First Lessons in Zoölogy
Elizabeth C. Agassiz

Bird Life Stories
John J. Audubon

My Land and Water Friends
M. E. Bamford

Locusts and Wild Honey
John Burroughs

Woodlands
Mordecai C. Cook

A Year Among the Birds
Wilson Flagg

The Out Door World
W. Furneaux

The Great World's Farm
Selina Gaye

Monsters of the Sea
Chips from the Earth's Crust
J. Gibson

Sharp Eyes
William H. Gibson

Practical Forestry
John Gifford

Along the Florida Reefs
Charles F. Holder

About Pebbles
Alpheus Hyatt

Country Cousins
Ernest Ingersoll

History of a Mouthful of Bread
Jean Macé

Under Foot
L. D. Nicholls

Underground Treasures
James Orton

Among the Night People
C. D. Pierson

Ethics of the Dust
John Ruskin

The Sea Children
Walter Russell

Aspects of the Earth
Nathaniel S. Shaler

The Vacation Club
Ada J. Todd

The Complete Angler
Izaak Walton

Half Hours in Field and Forest
Half Hours with a Naturalist
J. G. Wood